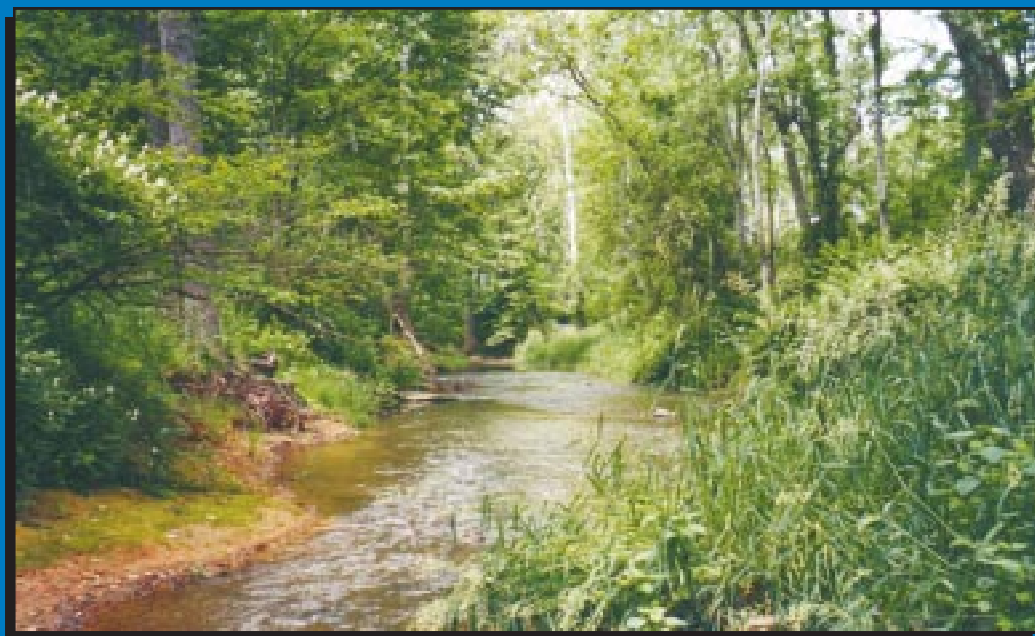
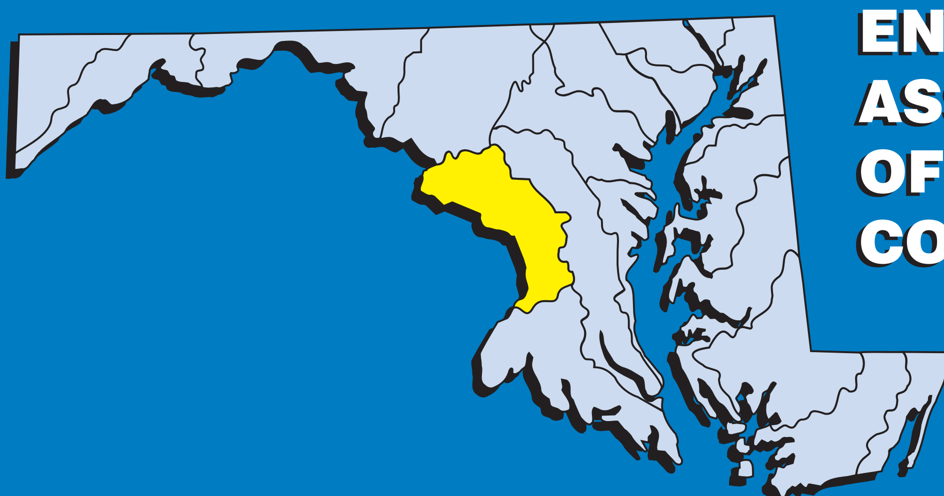
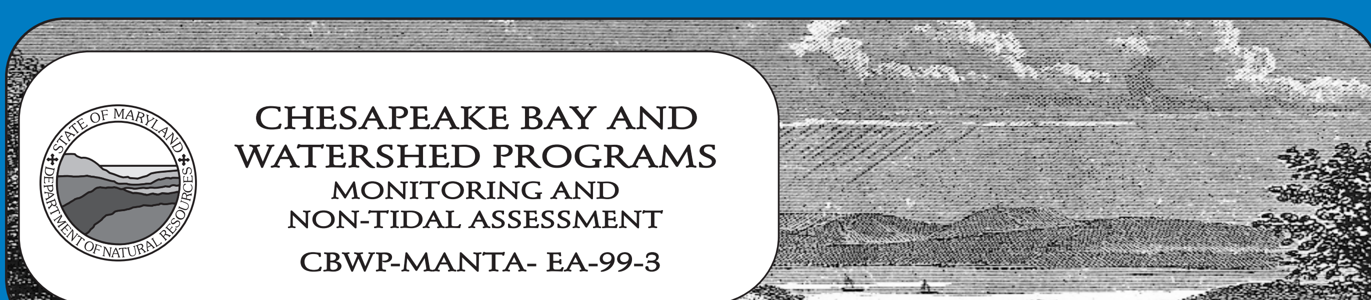
POTOMAC WASHINGTON METRO BASIN





ENVIRONMENTAL ASSESSMENT OF STREAM CONDITIONS



CHESAPEAKE BAY AND WATERSHED PROGRAMS
MONITORING AND NON-TIDAL ASSESSMENT

CBWP-MANTA- EA-99-3

Parris N. Glendening
Governor

Kathleen K. Townsend
Lieutenant Governor

A message to Maryland's citizens

The Maryland Department of Natural Resources (DNR) seeks to preserve, protect and enhance the living resources of the state. Working in partnership with the citizens of Maryland, this worthwhile goal will become a reality. This publication provides information that will increase your understanding of how DNR strives to reach that goal through its many diverse programs.

Sarah Taylor-Rogers
Secretary

Stanley K. Arthur
Deputy Secretary

Maryland Department of Natural Resources
Tawes State Office Building
580 Taylor Avenue
Annapolis, Maryland 21401

Toll free number: 1-(877) 620 8DNR x8611
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FOREWORD

The Maryland Department of Natural Resources (MDNR), Monitoring and Non-tidal Assessment Division prepared this report with financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the National Oceanic and Atmospheric Administration (NOAA). The report was funded in part by MDNR's Coastal Zone Management Program pursuant to NOAA Award No. NA770Z0188. In addition to this report, basin reports are also being prepared for the Lower Susquehanna, Ocean/Coastal, West Chesapeake and Pocomoke basins as part of this project.

On the cover. Great Seneca Creek in Montgomery County. Photo by Niles Primrose.

Much of this report is based on results of the Maryland Biological Stream Survey (MBSS), a program funded primarily by the Power Plant Research Program and administered by the Maryland Department of Natural Resources. Field data for the Potomac Washington Metro basin was collected by the Maryland Department of Natural Resources. Analysis of water chemistry samples was conducted by the University of Maryland's Appalachian Laboratory (AL) under Contract No. MA97-001-003. Much of the initial data analysis for this report was conducted by Versar, Inc. under Contract No. PR-96-055-001\PRFP44 to MDNR's Power Plant Assessment Division.

This report also uses 1997 results from the Montgomery County Countywide Stream Protection Strategy (CSPS) to further identify conditions within the Montgomery County portion of the Potomac Washington Metro basin.

This report helps fulfill two outcomes in MDNR's Strategic Plan: 1) A Vital and Life Sustaining Chesapeake Bay and Its Tributaries, and 2) Sustainable Populations of Living Resources and Healthy Ecosystems.

ACKNOWLEDGMENTS

We are grateful to Matt Kline, Mick Burkett, Dave Neely, Rod McCleod, Doug Orr, Amy Gotesfeld, Molly Kline, Sandy Davis, Todd Grote, Matt Habersch, and Brent Murry for long hours spent in the field. We are also grateful to Katie Meagher of AL for long hours and weekends spent in the laboratory to ensure that holding times and quality control measures were met for water samples. We thank Janis Chaillou and the Versar landowner permission crew for ensuring that permissions to sample streams on private property were obtained in a timely fashion. We also thank MDNR's Marty Hurd for providing Geographic Information Systems (GIS) support. We are grateful to Ron Klauda of MDNR, and Keith Van Ness of Montgomery County Department of Environmental Protection for editing and Dung Nguyen for cover design.

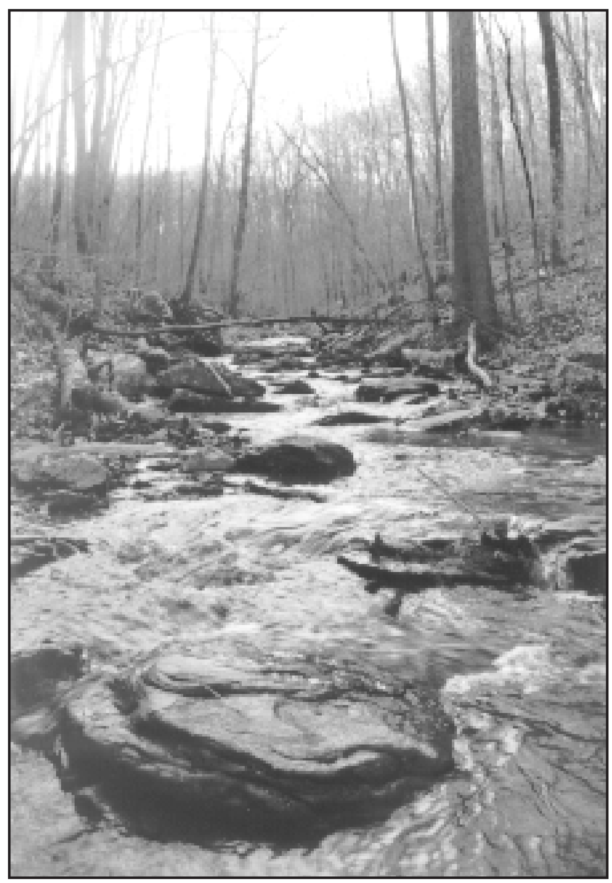

Photo by Niles Primrose

Little Seneca Creek, Montgomery County, Maryland.

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EXECUTIVE SUMMARY

This report describes existing aquatic resource conditions during 1997 in first, second, and third-order non-tidal streams in the Potomac Washington Metro basin in Maryland. The report also begins to assess water quality and habitat problems in the basin, as well as defining areas of high ecological quality. This information may prove useful as watershed-specific strategies for restoring water quality in Chesapeake Bay are developed and refined.

The primary source of information for this report is the Maryland Biological Stream Survey (MBSS) conducted by Maryland Department of Natural Resources (MDNR) in 1997 to characterize Maryland streams, including those within the Potomac Washington Metro basin. Although the primary focus of the MBSS is on acid deposition impacts, the survey is also being used for other purposes such as reporting on watershed conditions. The MBSS is a statewide survey of first, second, and third-order non-tidal streams designed to characterize current biological and habitat conditions and provide a basis for assessing future trends. The probabilistic design used for the survey, in which all streams have a known probability of being sampled, allows for quantitative estimates of stream characteristics and conditions. This approach is not unlike taking a random sample of voters to determine who is likely to win an election.

This report also uses 1997 results from the Montgomery County Countywide Stream Protection Strategy (CSPS) to further characterize conditions within the Montgomery County portion of the basin. While basin level data are useful to provide basin level characterizations, counties monitor local streams at a neighborhood scale that allows them to develop managment strategies that locate and prioritize impaired streams and develop management strategies to correct the impairment.

FINDINGS

Water Quality

None of the stream miles in the basin had summer dissolved oxygen (DO) levels lower than the state water quality criterion of 5 mg/L. This is consistent with the findings of Montgomery County (Van Ness 1999). This suggests that excessive loading of oxygen-demanding organic matter is not a problem for streams in the basin. However, there still may be some local problems, especially in areas of intense agriculture or urbanization.

None of the stream miles in the basin had acid neutralizing capacity (ANC) less than 0 μeq/L, indicating that streams in the basin were not chronically acidified. About 4% of the stream miles in the basin had ANC levels less than 200 μeq/L and are susceptible to episodic, storm-related acidification. The remainder of the stream miles had ANC levels greater than 200 μeq/L and are considered well-buffered and relatively immune to acid deposition impacts.

Acidity is not a widespread water quality problem in Potomac Washington Metro basin streams. Only 3% of the stream miles in the basin had pH less than 6 — the level below which significant adverse impacts on aquatic life are known to occur. None of the streams sampled had pH values below 5.

Elevated nitrogen levels (nitrate-nitrogen greater than 1 mg/L) occurred at 81% of the stream miles in the basin. The primary sources of nitrates appear to be agriculture and urban runoff, but sewer overflows and acid deposition are also likely contributors.

Physical Habitat

More than one-quarter (28%) of the stream miles in the basin were rated Poor or Very Poor for instream habitat. Most instream habitat problems result from the removal or loss of woody debris, channelization, sedimentation, and riparian zone deforestation.

Twenty-five percent of the stream miles in the Potomac Washington Metro basin were artificially straightened or channelized in some way (Appendix page D-4 describes what is meant by artifically straightened or channelized). Heavily channelized streams are generally shallow, with little habitat for living resources, while downstream areas suffer from increased flooding problems. Channelization also causes reduced retention and rapid transport of nutrients into Chesapeake Bay.

Over 20% of the stream miles in the basin had unstable or moderately unstable stream banks. In contrast, over 50% of the stream miles had highly stable banks. Eroding stream banks degrade available aquatic habitat and may be an important source of sediment and nutrients that are transported downstream to Chesapeake Bay.

In general, riparian zones along streams in the basin were in Fair condition. One-third of the Potomac Washington Metro basin stream miles had forested riparian zones greater than 50 meters wide. However, over one-quarter (28%) of the stream miles had unvegetated riparian zones and thus were not protected against runoff.

Based on MDNR's Physical Habitat Index, over one-half (53%) of the stream miles in the Potomac Washington Metro basin had Poor or Very Poor physical habitat, and less than one-tenth (7%) had Good habitat.

Fish

A total of 61 fish species were collected in the basin, including 5 gamefish species: largemouth bass, smallmouth bass, chain pickerel, brown trout, and rainbow trout. Largemouth bass were the most abundant gamefish collected, whereas rainbow trout were the least abundant.

Over 4.8 million fish live in non-tidal streams in the basin. The most abundant fish species was blacknose dace, a pollution-tolerant species, estimated at more than 1.4 million individuals.

Based on MDNR's Index of Biotic Integrity (IBI) for fish, about 16% of the stream miles were in Good condition, while 17% of the stream miles were in Very Poor condition. The remaining stream miles (39%) were assessed as either Fair or Poor. About 28% could not be rated because fish IBIs for very small streams have not yet been developed by MDNR.

Benthic Macroinvertebrates

More than 40% (153) of the 350 stream-dwelling benthic macroinvertebrate genera found in Maryland were collected in the basin. Dominant genera were non-biting midges. Rare genera were a caddisfly, a stonefly, and a mayfly.

Based on MDNR's benthic macroinvertebrate IBI, approximately 65% of all stream miles in the basin were assessed as Poor or Very Poor. Only 8% of all stream miles were rated as Good.

Reptiles and Amphibians

Reptiles and/or amphibians were present at approximately 90% of the sites sampled in the Potomac Washington Metro basin. A total of 24 species of frogs, turtles, salamanders, snakes, and lizards were collected.

Summary

The major impacts to non-tidal streams in the basin appear to be nutrient enrichment, stream bank instability, and lack of functional riparian buffers. Although many streams in the basin could have functioning riparian buffers, storm sewers penetrate urban stream buffers in areas built without storm water management (SWM) controls. These storm sewers discharge stormwater directly into local streams, bypassing the riparian buffer. Overall, the major impacts to non-tidal streams in the Potomac Washington Metro basin are stream alterations that result from urban activities.

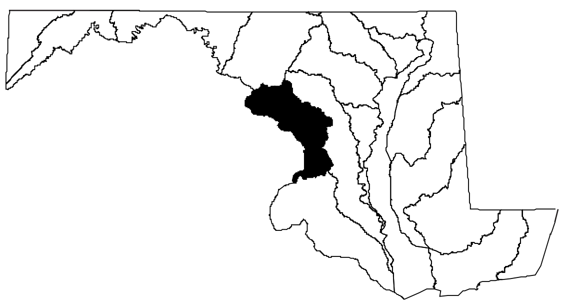
Extreme bank erosion causes increased sediment loads to Chesapeake Bay.

CHAPTER ONE

INTRODUCTION

Purpose of Report

This report describes aquatic resource conditions in first, second, and third-order non-tidal streams in the Potomac Washington Metro basin in Maryland during 1997. The report also begins to assess water quality and habitat problems in the basin, along with areas of high ecological value. We hope that this information will prove useful as specific strategies for restoring water quality in Chesapeake Bay and its tributaries are developed and refined.



The Potomac Washington Metro basin, one of Maryland's 18 major river basins, lies in the central part of the state and includes parts of Montgomery and Prince George's counties.

Stream Resources

The flowing waters of Maryland represent a vital lifeblood to its residents. In addition to providing a source of drinking water and water for agricultural and industrial uses, Maryland's streams and rivers provide recreational opportunities, attract tourists, and support commercially and recreationally important fish and shellfish. Forested riparian zones along streams and rivers contain some of the richest and most diverse plant and animal communities found anywhere in the state. These riparian zones also temper the effects of heavy rainfall and storm water runoff, shade the stream channel, increase bank stability, and contribute leaf litter and woody debris—sources of food and habitat for stream biota. In many cases, the aesthetic attraction of streams and rivers has served as the primary catalyst for economic re-development. Nearly all of the rivers and streams in Maryland, including those which drain to the Potomac Washington Metro basin, drain into Chesapeake Bay — therefore the quality of streams and rivers has a direct impact on the health of the Bay. As most Marylanders know, the Chesapeake Bay is one of Maryland's most important economic and natural resources.

In spite of these values, Maryland's streams and rivers have been abused and neglected, often converted to flood routing systems or used as drains for unwanted wastes. Increasingly, Marylanders are realizing that our mistreatment of natural resources is neither economically nor environmentally sustainable. Efforts are being made to restore degraded stream systems and to protect healthy streams. In the end, the success of these efforts will be determined by how much we cherish these most valuable natural gifts.

Information Sources for This Report

The primary data source for this report is the 1997 Maryland Biological Stream Survey (MBSS) conducted by Maryland Department of Natural Resources (MDNR). In addition, 1994 MBSS data have also been used where appropriate. The MBSS is a statewide survey of first, second, and third-order streams designed to characterize current biological and habitat conditions and provide a basis for assessing future trends. The probabilistic design (all streams have a known probability of being sampled and sites are randomly selected for sampling) used for the survey allows unbiased estimates of stream characteristics and conditions. For example, the abundance of a given fish species in an entire basin can be validly estimated using the MBSS design. Because first, second, and third order streams represent approximately 95% of the non-tidal stream miles in the Potomac Washington Metro basin, MBSS results should accurately represent overall stream quality in the basin. Examination of conditions in small streams also help to identify specific problem areas where local protection, enhancement, and restoration efforts could be focused.

This report also uses 1997 results from the Montgomery County Countywide Stream Protection Strategy (CSPS) to further characterize conditions within the Montgomery County portion of the basin.

While basin level data are useful to provide basin level characterizations, counties monitor local streams at a neighborhood scale that allows them to develop managment strategies that locate and prioritize impaired streams, and develop management strategies to correct the impairment.

To provide some comparison of present and past conditions, historical information is presented where appropriate and available. In addition, information on land use, hydrology, and other aspects of the basin is also presented so that the conditions observed in streams can be placed in context of human activity.

CHAPTER TWO

BASIN DESCRIPTION

The following chapter uses existing information to provide an overview of the Potomac Washington Metro basin, including ecological, recreational, and economic resources. This overview provides a context for interpreting the assessment of stream conditions found in Chapter 4.

History

Native Americans lived in the Potomac Washington Metro basin for thousands of years before the arrival of European settlers. For example, the Piscataway Indians were native to the basin. However, by 1660 a reservation had been established in the southwest corner of present day Montgomery County. The Piscataways moved to an unsettled area of Virginia following a conflict in 1697 (Hienton 1972).

Captain John Smith first sailed up the Potomac River in 1608, and Captain John Spelman first traded in this area as early as 1609. In 1737, the entire length of the river was surveyed by Lord Fairfax, from its mouth to its source, after King Charles decreed that the Potomac River would be the dividing line between Maryland and Virginia. Although Oxon Hill was settled as early as 1683, upriver movement by settlers was rather slow and grants of large tracts of land were not made until the 1700s (Farquhar 1972). In 1791, part of Montgomery County was ceded as land for the creation of the Nation's Capital, referred to as Federal City or the territory of Columbia. The Nation's Capital quickly evolved into the major commerical hub for the basin because the rivers could be navigated by boat. The fertile lands in the basin were widely used for agriculture. After the completion of the Baltimore and Ohio Railroad in 1842 and the Chesapeake and Ohio Canal in 1850, coal and agricultural products were transported more readily throughout the basin; such transportation also more readily allowed the introduction of the innovations of the Industrial Revolution (Cummins 1994).

Basin Characteristics

The Potomac Washington Metro basin, which lies between the Middle Potomac basin and the Lower Potomac basin, includes portions of Montgomery and Prince George's counties. Draining approximately 427 square miles, the basin covers approximately 5% of the state. Major tributaries include the Anacostia River, Rock Creek, Piscataway Creek, and Seneca Creek.

The basin lies within two physiographic provinces: the Piedmont and the Coastal Plain. The Piedmont Province, an area characterized by rolling hills and rather deeply incised stream valleys, is found in the northwestern two-thirds of the basin. The southeastern one-third of the basin lies in the Coastal Plain Province, which contains mostly sandy soils and fairly flat landforms. The fall line, a sinuous, poorly defined line characterized by the presence of rapids and waterfalls, separates the Coastal Plain province from the Piedmont .

Much of the forested area of the Potomac Washington Metro basin is dominated by stands of tulip popular, red maple, black gum, white oak, black cherry, and mockernut and pignut hickory (Brush et al. 1977). Along the floodplains of most tributaries in this basin, river birch, green ash, and sycamore are the dominant tree species. Around Darnstown, a unique forest association exists called the shingle oak association, consisting primarily of shingle oak, black oak, black cherry, mockernut hickory, white oak, and red maples.

In the 1950s and 1960s, several government agencies advocated the planting of a non-native shrub called multiflora rose as a means to enhance wildlife habitat on farms and in backyards. Since then, this species has spread into every drainage basin in the state and it continues to spread today. As a result, this introduced species now constitutes a significant threat to efforts to restore lost native vegetation along streams.

Multiflora rose is an opportunistic plant that colonizes cleared areas such as timber cuts and pastures—often so completely that virtually no other plants can compete with it. Because aquatic insects have adapted over thousands of years to feed on leaves fallen from native trees and shrubs, the takeover by multiflora rose is reducing the amount of food available for them. This, in turn, has very likely led to impacts on our native fish communities which depend upon insects to survive. An additional problem is that unlike mature trees whose root systems typically extend below the water level of a stream, the roots of multiflora rose do not protect the lower stream bank where erosion is most severe. Like many other introductions of non-native species, the introduction of multiflora rose has resulted in unforseen negative consequences—today, many riparian areas in the basin are virtually impenetrable because of the success of this noxious species.

Multiflora Rose (*Rosa multiflora*)

The soils in the Potomac Washington Metro basin reflect the two physiographic provinces the basin spans: Piedmont and Coastal Plain. The soils in the southeast portion of the basin range from the low slope, poorly drained silty soils to more sloped, well drained, easily eroded, sandy and loamy soils in the uplands. The northwest portion of the basin has very little unsloped land. Most of the soils are well drained, silty and loamy soils that are more steeply sloped and generally less acidic than the soils in the southeast.

A total of 695 miles of first, second, and third-order non-tidal streams make up the Maryland portion of the Potomac Washington Metro basin, according to a 1:250,000 scale U.S. Geological Survey map. For a description of stream order, see Chapter 3. First order streams make up approximately 68% of the total non-tidal stream miles, while second and third order streams constitute 16% and 11%, respectively. Another 5% of all stream miles in the basin are fourth order or larger.

Climate in the basin is primarily continental, with short, moderately cold winters and long, warm summers. Average annual temperature is about 54 °F. The average annual precipitation over the last 30 years has been approximately 44 inches, ranging from 31 inches in 1982 to 61 inches in 1996. In general, February is the driest month, while May is the wettest month on average (NOAA 1997). In spite of the relatively even distribution of rain throughout the year, in any given year some months have very little rain while others may greatly exceed the average amount. Winds are generally from the northeast in the winter, becoming southwest in the summer.

Land Use and Human Population

Almost one-half (45%) of the Potomac Washington Metro basin is urban, while most of the remainder is forested (29%) or agricultural (22%) (MDNR 1997) (Figures 1 and 2). A small portion is classified as water, wetland or barren. Between 1990 and 1994, the area of forest and agricultural land in the basin declined slightly (around 1%), while the area of urban land increased (3%).

The Washington-Metropolitan region is one of the most densely populated areas in the country. Based on the 1990 census data, about 924,000 people lived in the Potomac Washington Metro basin. For comparison, national census data for 1990 indicated that the population of 8 states was less than this amount. Large urban areas in the basin include Rockville, Gaithersburg, and Wheaton. Between 1990 and 2020, the number of people who live within the Potomac Washington Metro basin is expected to increase by about 25% to about 1,220,000 (MDNR 1997).

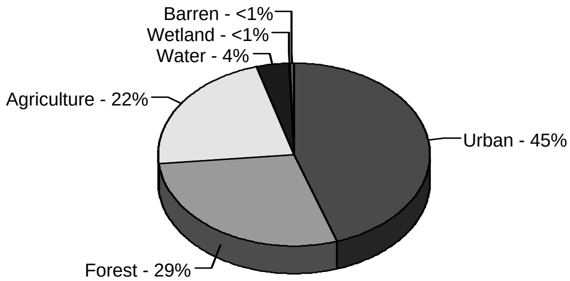


Figure 1. Land use in the Potomac Washington Metro basin (MOP 1994).

Water Quality

Water quality in the Potomac Washington Metro basin ranges from Fair to Good. Many impacts are likely related to storm events that result in urban runoff, sewer overflows, and high suspended sediment levels in tributaries adjacent to the District of Columbia (Elmore and Slunt 1984).

The Maryland Department of the Environment (MDE) classifies all surface waters in Maryland by their "designated use" (COMAR 1997). All waters of the state receive at least a Use I designation; that is, they are protected for contact recreation, fishing, and protection of aquatic life and wildlife. Use II waters are suitable for shellfish harvesting, while Uses III and IV are designated as natural and recreational trout waters, respectively. Additional designations are made for waters recognized for their function as drinking water supplies. Surface waters in the Potomac Washington Metro basin are designated as Use I, Use III, or Use IV.

County Government Monitoring

Montgomery and Prince George's County governments monitor the quality of streams in the Potomac Washington Metro basin. The Prince George's County Department of Environmental Resources monitors ecological conditions of streams at 60 sites in the county. Biological, water quality, and physical habitat data are collected using methods similar to the MBSS. The long term goal is to establish reference conditions in streams in the county.

Montgomery County Department of Environmental Protection (MCDEP) has been monitoring the ecological quality of streams in the Potomac Washington Metro basin since 1994. MCDEP determines the health of streams by evaluating fish and benthic macroinvertebrate communities using a provisional Index of Biotic Integrity (IBI), water chemistry, and stream physical habitat using methods comparable to the MBSS. Conditions at each monitoring site are compared to regional reference stream reaches and physical and biological conditions are aggregated to form an overall assessment for each site. Sites where pollutant stressors appear to be the primary cause of impairment are identified for follow up investigation. Sites where habitat or flow stressors appear to be the primary cause of impairment are identified for the development of watershed restoration action plans (MCDEP 1998). The latest available watershed reports and information on Montgomery County's monitoring program can be found at http://www.co.mo.md.us/services/dep/Watersheds/Biomon/biomon.html.

Data from Montgomery County monitoring stations have been used to develop the Montgomery County Countywide Stream Protection Strategy (CSPS). This report provides information on the current status of non-tidal streams and drainages at the neighborhood scale (a more specific scale than the basin level scale) within Montgomery County. More information on the CSPS can be found at http://www.co.mo.md.us/services/dep/Watersheds/csps/csps.html.

Recreational Resources

The Potomac Washington Metro basin offers many opportunities to participate in recreational activities. Some of the existing parks in the basin include Seneca

Creek State Park, Little Seneca Stream Valley Park, Great Seneca Extension Stream Valley Park, Ovid

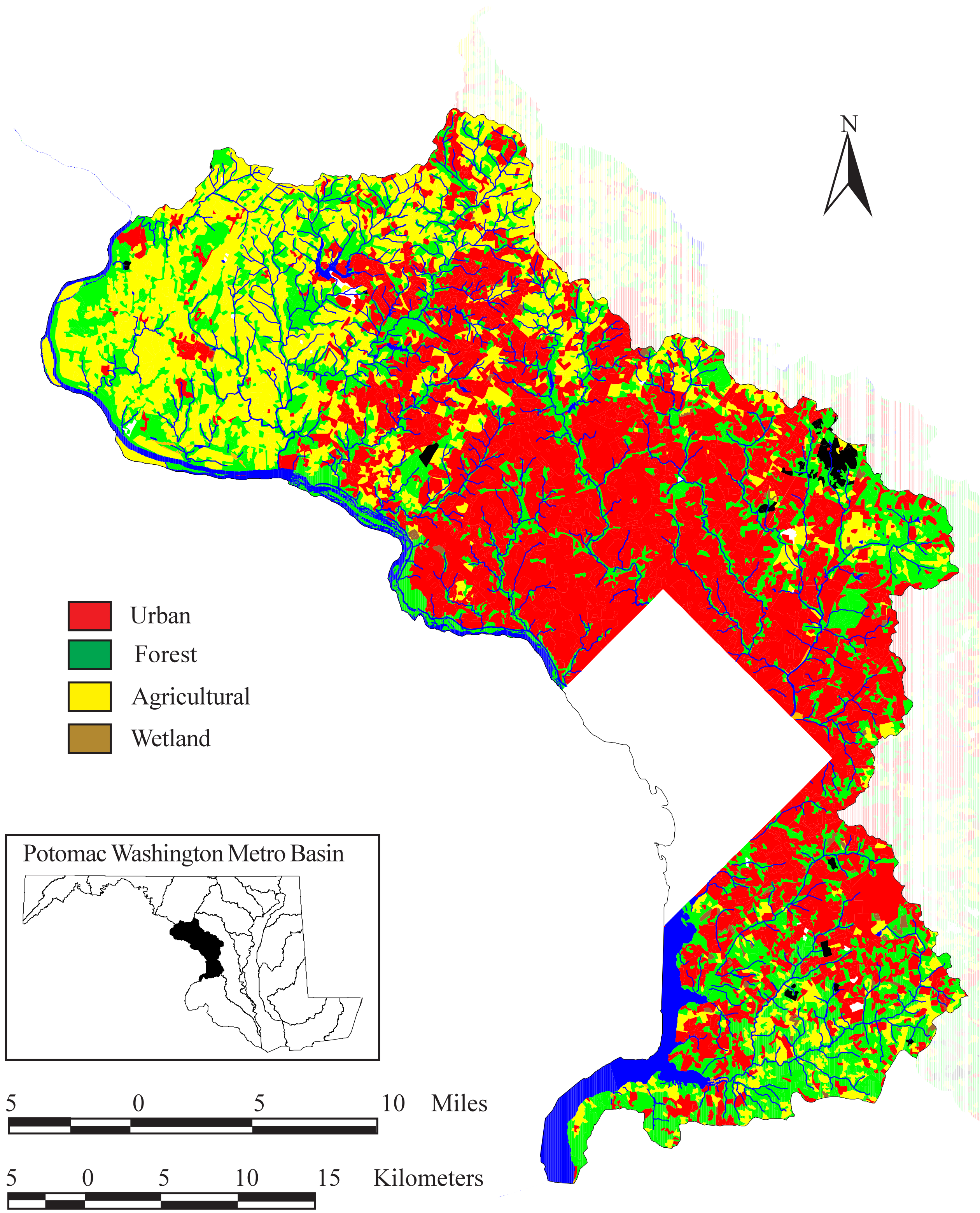


Figure 2. Land use (1994) in the Potomac Washington Metro basin (MOP 1994).

Hazen Wells Recreational Park, Goshen Recreational Park, Blockhouse Point Conservation Park, Greenbelt Park, Black Hill Regional Park, Upper and Lower Magruder Branch Stream Valley Park, Rock Creek Stream Valley Park, and Piscataway Park. These parks provide opportunities such as hiking, horseback riding, picnicking, biking, fishing, camping, and hunting. The C&O canal, which runs along the Potomac River from Georgetown in Washington, D.C. to Cumberland, is used for numerous activities. The canal towpath is used for hiking, biking, and camping, while portions of the canal itself offer canoeing opportunities. Lastly, the Potomac River is a great place for fishing, swimming, hunting, and boating.

Extractable Resources

The basin contains a number of mineral producers in both Montgomery and Prince George's counties. Sand and gravel are extracted from numerous areas within the basin and are used primarily as raw materials for local highway construction and maintenance. In addition, dimension mica-schist, dimension gneiss, quartzite, flagstone, and crushed serpentinite are extracted from four areas in Montgomery county and are used primarily for building and decorative purposes. Lastly, brick clay is extracted from a site in Prince George's county for brick production (MGS 1996).

Fishery Resources

The recreational fishery of the Potomac Washington Metro basin includes both fresh and saltwater fisheries. The waters of the Washington metropolitan area are known to support an exceptional largemouth bass fishery. Other fishes anglers seek include smallmouth bass, sunfish, catfish, carp, and American eels. During the spring and summer periods, striped bass, bluefish, yellow perch, white perch, shad, and herring are sought by anglers. Although few coldwater angling opportunities exist in the basin, Rock Creek and Little Seneca Creek and its tributaries contain natural trout areas (Elmore and Slunt 1984).

Citizen Involvement

During the last decade, an increasing number of concerned citizens have become involved in organizations and programs working to protect and restore Maryland's aquatic resources. Many such organizations focus their work on a particular river basin or stream. The Anacostia Watershed Society works to motivate citizens to take volunteer action to restore and protect the Anacostia River and its tributaries. Activities include visual surveys, macroinvertebrate surveys, river tours, and the reporting of contamination or other unusual occurrences in the river.

On a broader scale, the Potomac River Greenways Coalition advocates and coordinates the conservation and enhancement of the Potomac River. The group focuses on stewardship of a network of greenways as a protected corridor of natural, historic, scenic, and recreational resources along the Potomac and its tributaries (ACB 1996).

To find out how to get involved in water quality monitoring and watershed issues in the Potomac Washington Metro basin, contact:

Anacostia Watershed Society
5110 Roanoke Place #101
College Park, Maryland 20740

Audubon Naturalist Society
8940 Jones Mill Road
Chevy Chase, Maryland 20815

C and O Canal Group
1180 Harbor Oaks Drive
Crownsville, Maryland 21032

Eyes of Paint Branch
P.O. Box 4464
Silver Spring, Maryland 20914

Izaak Walton League of America
707 Conservation Lane
Gaithersburg, Maryland 20878

Maryland Save our Streams
258 Scotts Manor Drive
Glen Burnie, Maryland 21061

Potomac River Greenways Coalition
6110 Executive Boulevard, Suite 300
Rockville, Maryland 20852-3903

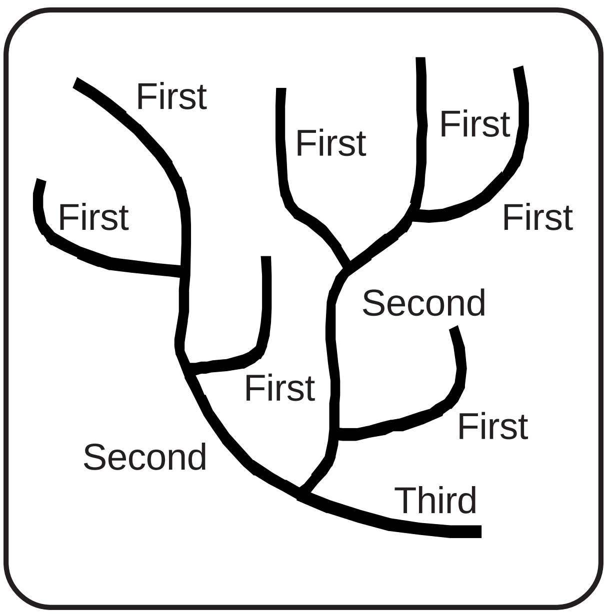
Sierra Club
103 North Adams Street
Rockville, Maryland 20850

Stream Striders
1109 Spring Street
Suite 802
Silver Spring, Maryland 20910

Trout Unlimited
2916 Trellis Lane
Abingdon, Maryland 21009

CHAPTER THREE
SURVEY DESIGN AND SAMPLING METHODS

This chapter briefly outlines the approach used to assess the stream resources of the Potomac Washington Metro basin. The sampling design used for this assessment differs from other stream surveys that have been conducted in Maryland. Randomly-selected sampling sites for the MBSS on first, second, and third order (as determined at the 1:250,000 scale) non-tidal streams (Strahler 1964) were chosen by computer rather than selected by the investigator. This approach allows estimates to be calculated for an array of ecological factors such as fish density and stream habitat condition. Non-randomly selected sites were also sampled to provide additional information on fish distributions. Figure 3 shows the location of random and non-random sampling sites during the 1994 and 1997 MBSS.



STREAM ORDER
Stream order is a simple way to measure stream size. The smallest permanently flowing stream is termed first-order, and the union of two first-order streams creates a second-order stream. A third-order stream is formed where two second-order streams join. Stream order is related to watershed area.

After landowner permissions were obtained, sample sites were located with Global Positioning System (GPS) receivers, fish and benthic macroinvertebrates were collected, and physical habitat features were evaluated using methods patterned after EPA's Rapid Bioassessment Protocols (Plafkin et al. 1989). Reptiles, amphibians, and mussels were also surveyed on a presence/absence basis. Water quality was sampled using protocols previously established for acid rain studies in Maryland (MDNR 1988). Because the primary purpose of the MBSS is to assess the effect of acid rain on Maryland streams and rivers, other important water quality measures such as phosphorous and turbidity were not measured.

Because most stream sites in the Potomac Washington Metro basin were on private land, landowner permissions were sought for each randomly-selected site. This procedure required contact with property owners, usually by phone. Overall, 97% of the landowners contacted in the basin gave MDNR permission to have streams on their property sampled by the MBSS.

All catchments draining to the MBSS sampling sites were delineated and land use (MOP 1994) was estimated for each. Throughout all sampling and data management activities, an extensive Quality Control program was employed. Additional technical information about the methods used to survey streams and survey results can be found in the Appendices of this report, in Roth et al. (1999) and in Kazyak (1996).

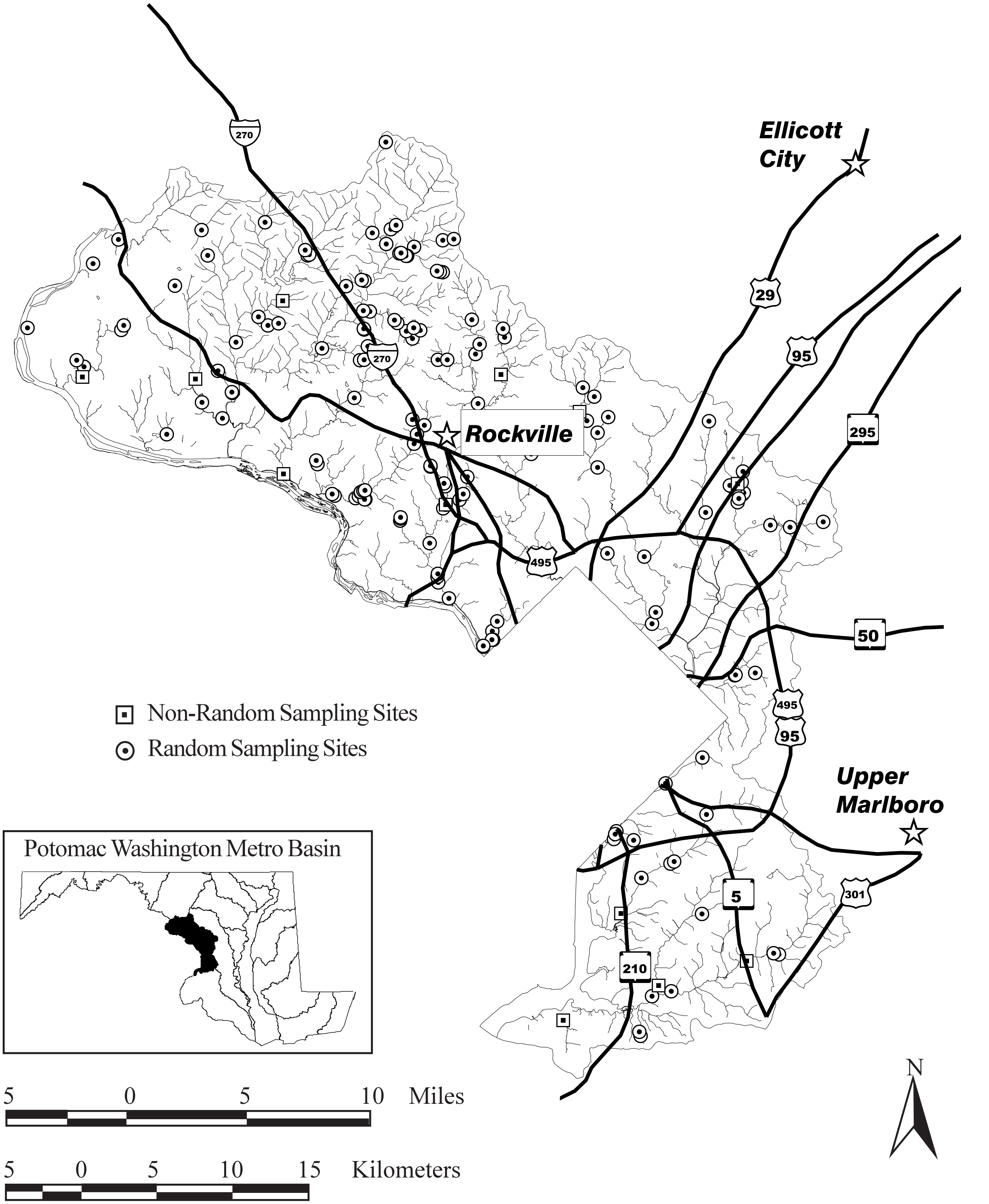


Figure 3. Location of 1994 and 1997 sampling sites in the Potomac Washington Metro basin. Major highways, population centers, and other features are shown for reference. Inset map shows the basin's location within Maryland.

CHAPTER FOUR
CURRENT STATUS OF AQUATIC RESOURCES

This chapter uses 1997 Maryland Biological Stream Survey (MBSS) data from 71 randomly selected sampling sites in the Potomac Washington Metro basin to describe the current status of non-tidal streams. In addition to the 1997 data, 1994 data were used to assemble a list of fishes and herpetofauna that reside in the basin. A map of the 1994 and 1997 MBSS sites in the basin is shown in Figure 3. A list of the streams sampled in 1997 is presented in Appendix B. This chapter also uses 1997 results from the Montgomery County Countywide Stream Protection Strategy (CSPS) to further characterize conditions within the Montgomery County portion of the basin.

GENERAL CHARACTERISTICS OF POTOMAC WASHINGTON METRO BASIN STREAMS

Of the 71 sites sampled in the basin in 1997, 19 (27%) were in the Coastal Plain Physiographic Province. The remainder were in the Piedmont Plateau, where streams tend to be of moderate stream gradient with riffles that aerate the water. This aeration helps replenish dissolved oxygen (DO) lost because of over-enrichment. Stream gradient ranged from 0.01% to 3.0% (A stream with a 3% gradient drops 3 meters in elevation for every 100 meters of stream channel length). The width of streams sampled varied considerably, from less than 1 m to about 21 m throughout the sampling sites.

WATER QUALITY

During the spring index period, water grab samples were collected at each site for laboratory analysis of pH, acid neutralizing capacity (ANC), conductivity, sulfate, nitrate-nitrogen, and dissolved organic carbon (DOC). Summer index period sampling included *in situ* measurements of dissolved oxygen (DO), pH, temperature, and conductivity at each site to further characterize water quality conditions. Water chemistry data from the 1997 quantitative sites are presented in Appendix C.

Dissolved Oxygen

All stream miles within the Potomac Washington Metro basin had dissolved oxygen concentrations above the state water quality criterion of 5 mg/L (COMAR 1997). These results indicate that runoff of oxygen-demanding materials into basin streams does not produce widespread DO-related problems. However, the same runoff which enters these streams ultimately reaches Chesapeake Bay and can contribute to water quality problems there.

> Dissolved oxygen (DO) is one of the most basic requirements of aquatic organisms, thus DO levels play an important role in shaping biological communities in streams. DO in streams may be low due to nutrient-rich runoff and groundwater inputs from urban and agricultural areas, oxygen demanding organic chemicals in point source discharges, or the breakdown of naturally-occurring organic material such as leaves. The State of Maryland has established a minimum surface water criterion of 5 milligrams per liter (mg/L, also known as parts per million) for DO. When DO is low (i.e., less than 5 mg/L), only those organisms adapted to low DO can persist. In the Piedmont Plateau, streams typically have riffles, where water bubbles over rocks. Riffles help to keep DO levels high by aerating the water. During MBSS summer sampling, dissolved oxygen is measured only once during the day. In heavily impacted streams, DO may drop severely during the early morning hours because oxygen production from plants ceases at night while oxygen consumption by both plants and animals continues.

pH and Buffering Capacity

In 1997, 97% of the stream miles in the basin had pH values greater than 6, indicating that acidity is not a widespread problem. Significant adverse impacts on aquatic life are known to occur for some species when pH values drop below 6, and for most species at pH less than 5. None of the stream miles had pH values less than 5.

None of the stream miles had acid neutralizing capacity (ANC) values less than 0 μeq/L, indicating that none of the streams in the basin were chronically acidified (Figure 4). About 4% of the stream miles had ANC levels less than 200 μeq/L and thus may be susceptible to periodic acidification during larger storms. Streams with ANC greater than 200 μeq/L are considered well-buffered and probably not susceptible to acid deposition impacts.

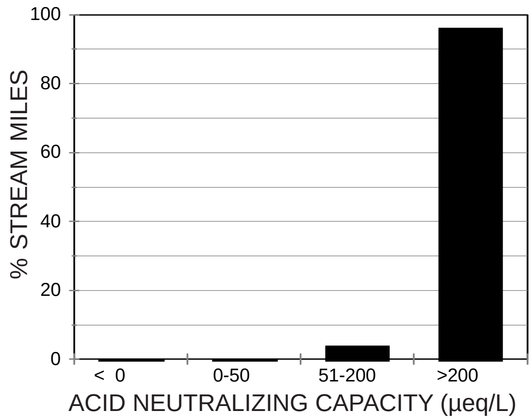


Figure 4. Acid neutralizing capacity (ANC) in non-tidal streams of the Potomac Washington Metro basin (1997).

Acidity is an important aspect of stream health. The balance between free hydrogen ions (which increase acidity) and negative ions (which decrease acidity) is measured as pH. The capacity of soil or water to absorb acids without changing the ion balance is known as its buffering capacity, measured as alkalinity or Acid Neutralizing Capacity (ANC). Streams with ANC less than 0 µeq/L are acidic and have no buffering capacity. Streams with baseflow ANC between 0 and 200 µeq/L are only moderately buffered and may periodically have low pH levels during rain or snowmelt events. Those streams with ANC greater than 200 µeq/L are well-buffered. Under acidic conditions, certain metals such as aluminum are dissolved into water and reach levels that can be lethal to aquatic organisms. Acidity in streams is affected by rain, snow, fog, and atmospheric dust, geology and soil characteristics, and organic matter.

Acidification of streams can be either chronic (i.e., year-round) or episodic (seasonal or storm event-related), depending on the capacity of the stream to buffer acid inputs. Chronically acidified streams generally contain only those organisms highly tolerant of acid conditions. In contrast, streams which are only episodically acidified can and often do support less tolerant "invaders" from better buffered downstream areas during summer low flow periods.

Nitrates and Dissolved Organic Carbon

Eighty-one percent of all stream miles in the basin had nitrate values greater than 1 mg/L, suggesting that excess nutrients are a widespread environmental problem (Figure 5). Because these results represent primarily spring baseflow conditions, and by inference groundwater concentrations, reductions in nitrate loading in the basin may not be apparent for many years to decades until groundwater sources are purged of their relatively high nitrogen levels, even if point and non-point sources of nitrates are reduced in surface waters.

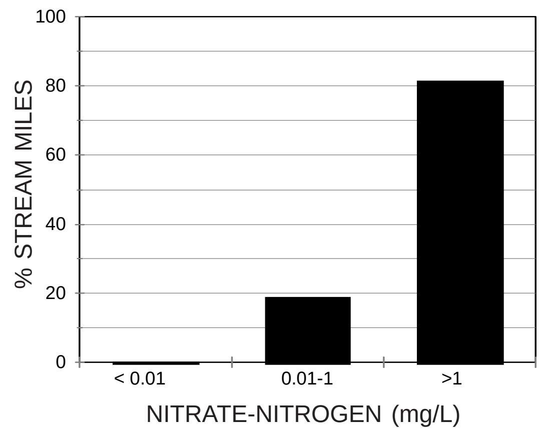


Figure 5. Nitrate-nitrogen concentration in non-tidal streams of the Potomac Washington Metro basin (1997).

Two important indicators of the sources of acidity in Maryland streams are nitrate and dissolved organic carbon (DOC).

One important source of nitrates in Maryland streams is deposition from the atmosphere. However, leaching into groundwater and direct runoff of fertilizers and animal wastes used on agricultural lands, discharges from sewage treatment plants, and leaking of septic systems are more important sources of nitrates to streams. Stream nitrate concentrations greater than 1 mg/L are elevated compared to undisturbed streams (Morgan 1995).

The primary source of DOC in streams is leachate from decaying leaves and other plant material that are natural sources of organic matter found within the stream drainage network itself, especially wetlands. DOC concentrations greater than 10 mg/L indicate that organic acids contribute significantly to overall acidity, but DOC levels between 5 and 10 mg/L also indicate that natural sources are contributing to overall acidity in a stream (Morgan 1995).

Approximately ninety percent of all stream miles in the basin had DOC levels less than 5 mg/L and only 3% of stream miles had DOC levels greater than 10 mg/L. These findings indicate that natural sources of acidity are not a significant influence on stream water quality in the basin (Figure 6).

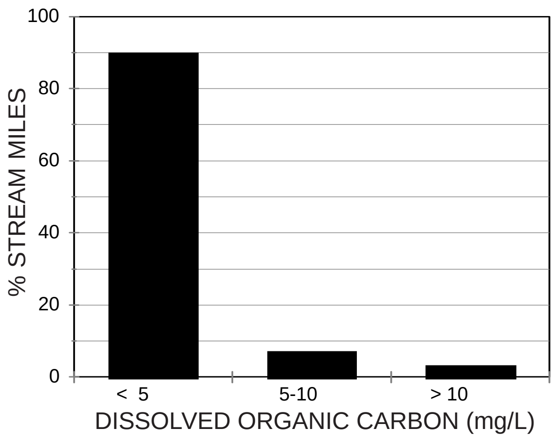


Figure 6. Dissolved organic carbon (DOC) in non-tidal streams of the Potomac Washington Metro basin (1997).

PHYSICAL HABITAT

Many physical habitat characteristics of streams are important determinants of ecosystem structure and function. Although a large number of habitat variables are measured by the MBSS, they can be grouped into four general categories: instream habitat, channel character, riparian zone, and aesthetics/remoteness. Most variables are classified (in order of decreasing habitat quality) as either Good, Fair, Poor, or Very Poor. In addition to examining habitat characteristics separately, it is also possible to aggregate key variables into a single index of physical habitat quality. Such an index is presented at the end of this section, and a description of MBSS physical habitat variables is included in Appendix D.

> What is habitat?
> The physical/chemical theater in which the ecological play takes place; it is a template for the biota, their interactions, and their evolution (ITFM 1995).

Instream Habitat

The complexity and stability of habitat in a stream typically has the strongest relationship to abundance and diversity of the biological communities that occur there. Important instream habitat characteristics include: 1) quality, composition, and heterogeneity of the stream bottom; 2) diversity of depth and flow; and 3) amount and quality of stable habitat for fish shelter and attachment sites for benthic macroinvertebrates.

Over one-half (54%) of all stream miles in the Potomac Washington Metro basin were rated Fair for instream habitat, while only 18% were rated Good. The remaining 28% of the stream miles in the basin were rated Poor or Very Poor (Figure 7). Most instream habitat problems result from the removal or loss of woody debris from stream channels in agricultural or urban areas; little to no buffer between pastures, croplands, urban lands and streams; increases in sediment loads; and modification of stream channels because of increased runoff. These impacts to instream habitat are common when lands are developed for agricultural or urban uses.

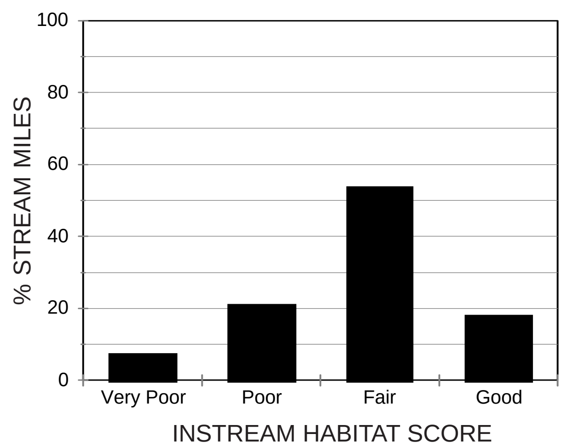


Figure 7. Instream habitat condition in non-tidal streams of the Potomac Washington Metro basin (1997).

Increased sediment loads tend to reduce the complexity and stability of the stream bottom, resulting in loss of habitat for fish and macroinvertebrates. Another common outcome is the covering or burial of stones by silt and sand in riffle areas. Since many benthic macroinvertebrates, such as mayflies and stoneflies, use the spaces between rocks as living quarters, high sediment loads reduce the amount of available habitat and reduce benthic macroinvertebrate diversity and abundance in streams.

Results from the MBSS indicate that only 12% of the stream miles in the Potomac Washington Metro basin were rated Poor or Very Poor in terms of embeddedness, while over one-half (53%) of the stream miles were rated Good (Figure 8). These results suggest that habitat impairment via smothering by fine sediment is not a major problem in streams of this basin compared to other areas of the state.

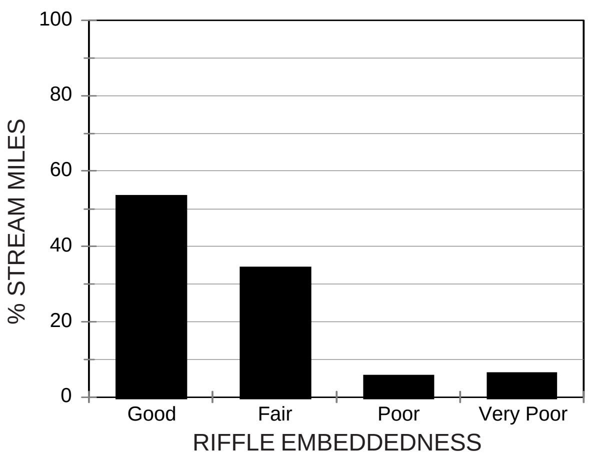


Figure 8. Riffle embeddedness in non-tidal streams of the Potomac Washington Metro basin (1997).

Another impact to instream habitat quality is the reduction in the abundance of wood (i.e., logs, limbs and rootwads) along stream banks and in stream channels compared to historical levels. Wood in streams may greatly enhance habitat quality for both fish and benthic macroinvertebrates by providing a diverse array of shelter, depths, and velocities. Woody debris also traps and retains leaves, a vital food supply for many benthic macroinvertebrates. By retaining organic matter in and near the stream channel, the export of nutrients to Chesapeake Bay is reduced.

A lack of woody debris and rootwads was clearly evident within the basin. There are about 50 pieces of woody material per stream mile in the basin. In addition, over one-third (37%) of all stream miles in the basin lacked any woody material. Maser and Sedell (1994) indicated that wood often controls 80% or more of the stream channel in streams within old growth forests; thus woody debris densities in the basin prior to extensive human disturbance were likely much higher than the most pristine stream sampled in 1997.

In addition to the effects still felt from the original clear cutting of the entire basin, a continuing cause of the reduced abundance of woody debris and rootwads in the basin is related to prevailing forestry practices. In today's managed forests, trees are rarely allowed to achieve senescence (old age and natural death); thus one of the vital and controlling elements of instream habitat (large dead trees and tree limbs) is largely prevented from falling into streams. In addition, woody debris that falls into streams during logging is routinely removed.

Channel Characteristics

Large-scale disturbances in the stream channel may result from watershed development or channel modification. Evidence of stream channel disturbance includes excessive bar formation, the presence of artificial structures (e.g., concrete armoring and rip-rap), reduced stream flows because of water removal for irrigation and other uses, and severe bank erosion.

Twenty-five percent of the stream miles in the basin are artificially straightened or channelized. During channelization, trees in the riparian zone are often cut and woody debris is removed from the stream channel to allow for efficient movement of water away from agricultural fields or housing developments. As a result, heavily channelized streams are generally shallow, with little habitat for living resources, while downstream areas suffer from increased flooding problems. Channelization also causes reduced retention and rapid transport of nutrients into Chesapeake Bay.

As lands within the basin were developed for agriculture and then urbanized, many miles of stream banks were destabilized and sand/silt bars formed in slow moving areas. Currently, over 21% of all stream miles in the basin have degraded channel conditions. Over 50% of the stream miles have stream banks that are stable (Figure 9), but many of these "stable" banks are concrete trapezoids which increase erosion problems in downstream areas. In general, instability of stream channels affects available habitat and increases the nutrient and sediment loads transported to Chesapeake Bay.

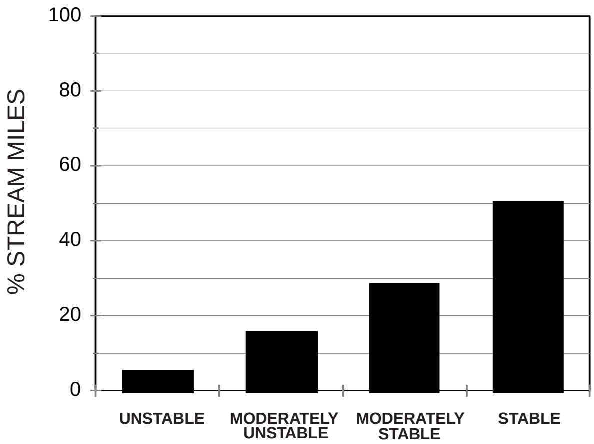


Figure 9. Bank conditions in the Potomac Washington Metro basin streams (1997).

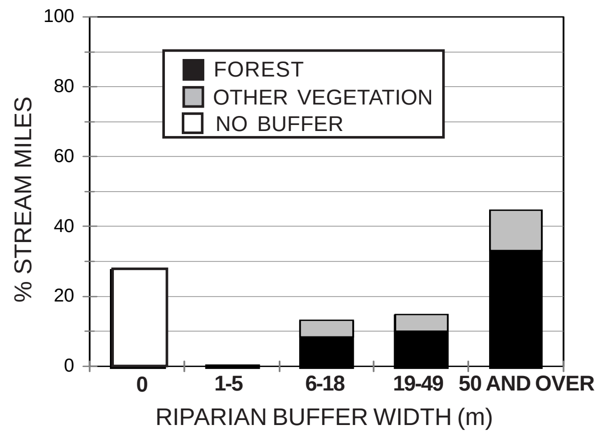


Figure 10. Riparian zone width and type in Potomac Washington Metro basin streams (1997). Other vegetation includes old field, mowed lawn, and tall grass.

Riparian Zone

Riparian zones are the areas alongside streams, rivers, and other waterbodies. When these areas are vegetated, they play a vital role in structuring and maintaining physical habitat, energy flow, and aquatic community composition. Vegetated (trees, shrubs, and grasses) riparian zones act as buffers by decreasing runoff and preventing particulate pollutants from entering streams (Plafkin et al. 1989). Trees and shrubs also provide energy inputs to the stream in the form of leaf litter and woody debris, stabilize stream channels, supply overhead and instream cover for fishes and other aquatic life, and moderate stream water temperature.

Conditions in the riparian zones of the Potomac Washington Metro basin streams were Fair in 1997 (Figure 10). Forest slightly dominated most riparian buffers in the basin and about 32% of the stream miles had forested riparian zones greater than 50 meters wide. However, over one-quarter (28%) of the stream miles had unvegetated riparian zones and thus were not protected against runoff. Forest cover along streams decreases exposure of the stream channel to direct sunlight and helps prevent warming of stream waters above their natural condition. Other vegetation types, such as old field, mowed lawn, and tall grass were common along streams in the basin.

What is the worst stream pollution problem?

When asked this question, many people will respond with one word..."trash". Although trash in and along streams is unsightly and undesirable, it is often not the primary cause of stream degradation. However, it may be a good indicator of upstream watershed conditions. The more people living or working in a watershed, the more likely trash will end up in the stream draining the watershed. Some groups conducting stream monitoring programs are developing indices based on the number of articles of trash (such as shopping carts) at a stream site. Quantifying stream characteristics such as trash will help us gauge our success in stormwater management, public education and even recycling.

Most stream miles in the basin were rated either Fair (33%) or Good (43%) based on the amount of human refuse at the site (Figure 11). However, 11% of the stream miles were rated Very Poor and contained excessive amounts of human refuse. Almost 60% of the stream miles were near or immediately adjacent to roads. Proximity to roads and the amount of human refuse present indicates human activities are prevalent near streams.

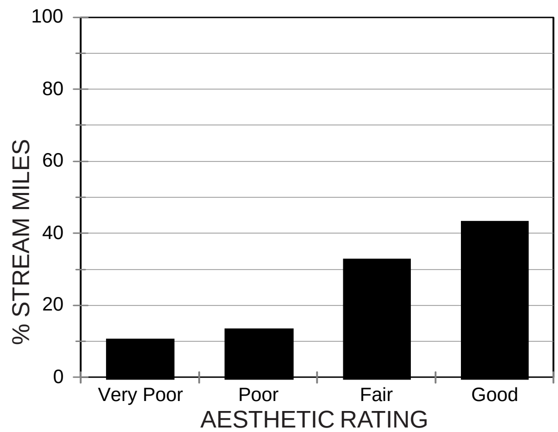


Figure 11. Aesthetic rating for non-tidal streams in the Potomac Washington Metro basin (1997).

HABITAT QUALITY BASED ON A PHYSICAL HABITAT INDEX (PHI)

In addition to evaluating habitat components individually, the MBSS has developed a provisional index which combines those aspects of physical habitat which have proven to be the best indicators of biological condition (Hall et al. 1999). Based on this index, more than one-half (53%) of the stream miles in the Potomac Washington Metro basin have Poor or Very Poor physical habitat, and less than 10% have Good habitat (Figure 12).

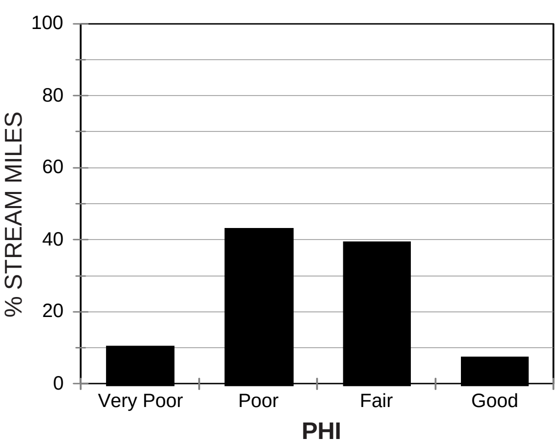
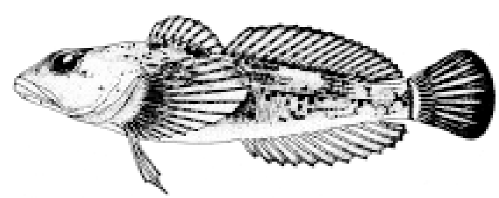


Figure 12. PHI for non-tidal streams in the Potomac Washington Metro basin (1997).

FISHERY RESOURCES

General Description

A total of 61 fish species representing 15 families were collected in the Potomac Washington Metro basin in first, second, and third order streams in 1994 and 1997. Fish sampling was conducted at 142 random sites and 14 non-random (presence/absence) sites. Population estimates for each species were calculated with the 1997 quantitative data and indicated that the total abundance of fish in first through third order streams in the basin was about 4.8 million. Basin-wide population estimates for individual species ranged from less than 100 individuals for species such as bluespotted sunfish and white catfish, to more than 1.4 million for blacknose dace (Table 1). The four most abundant species were blacknose dace (31%), Potomac sculpin (10%), mottled sculpin (8%), and creek chub (7%) (Figure 13).



Potomac Sculpin

The minnow family (Cyprinidae) had the greatest number of fish species (22), followed by the sunfish family (Centrarchidae) with 10 species. All other families were represented by five or fewer species.

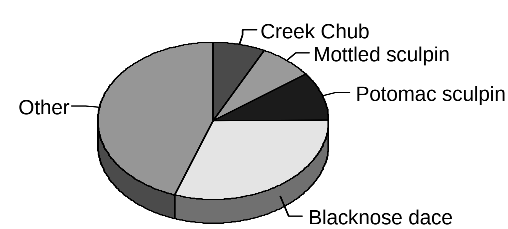


Figure 13. Percent of total abundance of the four most abundant fish species in the Potomac Washington Metro basin (1997).

Gamefish

Five species of gamefish were collected in the Potomac Washington Metro basin. Largemouth bass were the most abundant gamefish collected, with a density

Table 1. Estimated total abundance and percentage occurrence of fish species collected in the Potomac Washington Metro basin (first, second, and third-order non-tidal streams combined).

Family	Common Name	(Scientific Name)	Percentage Occurrence[1]	Population Estimate[2,3]	Standard Error
Petromyzontidae					
	American Brook Lamprey	*(Lampetra appendix)*	1.3	362	270
	Least Brook Lamprey	*(Lampetra aepyptera)*	3.2	854	525
	Sea Lamprey	*(Petromyzon marinus)*	1.3	2,066	1,906
Anguillidae					
	American Eel	*(Anguilla rostrata)*	43.6	46,290	9,063
Clupeidae					
	Gizzard Shad	*(Dorosoma cepedianum)*	0.6		
Esocidae					
	Chain Pickerel	*(Esox niger)*	3.8	777	567
	Redfin Pickerel	*(Esox americanus)*	0.6	194	194
Umbridae					
	Eastern Mudminnow	*(Umbra pygmaea)*	9.6	63,522	36,249
Cyprinidae					
	Blacknose Dace	*(Rhinichthys atratulus)*	83.3	1,491,012	168,888
	Bluntnose Minnow	*(Pimephales notatus)*	29.5	235,543	92,225
	Central Stoneroller	*(Campostoma anomalum)*	28.2	41,724	13,067
	Comely Shiner	*(Notropis amoenus)*	7.1	1,955	2,077
	Common Carp	*(Cyprinus carpio)*	3.2	596	492
	Common Shiner	*(Luxilus cornutus)*	29.5	32,114	9,116
	Creek Chub	*(Semotilus atromaculatus)*	72.4	354,275	73,917
	Cutlips Minnow	*(Exoglossum maxillingua)*	32.1	21,927	5,729
	Eastern Silvery Minnow	*(Hybognathus regius)*	2.6	452	510
	Fallfish	*(Semotilus corporalis)*	12.8	6,691	2,856
	Fathead Minnow	*(Pimephales promelas)*	1.3	65	67
	Golden Shiner	*(Notemigonus crysoleucas)*	16	84,417	72,223
	Goldfish	*(Carassius auratus)*	2.6	362	263
	Longnose Dace	*(Rhinichthys cataractae)*	50	169,352	89,079
	River Chub	*(Nocomis micropogon)*	4.5	888	624
	Rosyface Shiner	*(Notropis rubellus)*	1.3		
	Rosyside Dace	*(Clinostomus funduloides)*	53.2	142,534	51,808
	Satinfin Shiner	*(Notropis analostana)*	17.9	34,736	9,702
	Silverjaw Minnow	*(Notropis buccatus)*	26.3	35,030	19,463
	Spotfin Shiner	*(Cyprinella spiloptera)*	3.8	1,338	681
	Spottail Shiner	*(Notropis hudsonius)*	15.4	53,588	21,983
	Swallowtail Shiner	*(Notropis procne)*	32.1	115,659	35,186
Catostomidae					
	Creek Chubsucker	*(Erimyzon oblongus)*	20.5	67,143	52,377
	Golden Redhorse	*(Moxostoma erythrurum)*	2.6		
	Northern Hogsucker	*(Hypentelium nigricans)*	17.3	8,005	3,418
	Shorthead Redhorse	*(Moxostoma macrolepidotum)*	1.9		
	White Sucker	*(Catostomus commersoni)*	67.9	169,303	46,658

Table 1 (continued)

Family	Common Name	(Scientific Name)	Percentage Occurrence[2]	Population Estimate[3,4]	Standard Error
Ictaluridae					
	Brown Bullhead	*(Ameiurus nebulosus)*	7.1	66,038	56,770
	Channel Catfish	*(Ictalurus punctatus)*	0.6		
	Margined Madtom	*(Noturus insignis)*	3.2	14,763	10,042
	White Catfish	*(Ameiurus catus)*	0.6	65	65
	Yellow Bullhead	*(Ameiurus natalis)*	23.7	33,434	20,584
Salmonidae					
	Brown Trout	*(Salmo trutta)*	2.6	310	211
	Rainbow Trout	*(Oncorhynchus mykiss)*	4.5	246	169
Fundulidae					
	Banded Killifish	*(Fundulus diaphanus)*	4.5	2,688	2,227
	Mummichog	*(Fundulus heteroclitus)*	2.6	4,739	3,259
Poeciliidae					
	Eastern Mosquitofish	*(Gambusia holbrooki)*	4.5	2,049	1,705
Cottidae					
	Mottled Sculpin	*(Cottus bairdi)*	17.3	367,090	116,566
	Potomac Sculpin	*(Cottus girardi)*	28.2	487,544	107,960
Moronidae					
	White Perch	*(Morone americana)*	0.6	258	291
Centrarchidae					
	Black Crappie	*(Pomoxis nigromaculatus)*	1.3		
	Bluegill	*(Lepomis macrochirus)*	32.7	53,129	24,667
	Bluespotted Sunfish	*(Enneacanthus gloriosus)*	1.3	65	53
	Green Sunfish	*(Lepomis cyanellus)*	42.9	139,432	62,347
	Largemouth Bass	*(Micropterus salmoides)*	16.7	7,208	4,906
	Longear Sunfish	*(Lepomis megalotis)*	1.9		
	Smallmouth Bass	*(Micropterus dolomieu)*	14.1	969	501
	Pumpkinseed	*(Lepomis gibbosus)*	33.3	180,294	126,959
	Redbreast Sunfish	*(Lepomis auritus)*	42.3	61,478	12,469
	Rock Bass	*(Ambloplites rupestris)*	6.4	1,752	818
Percidae					
	Fantail Darter	*(Etheostoma flabellare)*	37.2	168,758	52,818
	Greenside Darter	*(Etheostoma blennioides)*	18.6	11,299	6,691
	Tessellated Darter	*(Etheostoma olmstedi)*	45.5	86,935	18,681

1 Percent of all random and non-random sites where each species was collected, including 1994 sites.
2 Total abundance (number per basin) adjusted for capture efficiency (Heimbuch et al. 1997).
3 Non-random site information was not used in calculating population estimates.

of 11 per stream mile. The basin-wide abundance of largemouth bass was about 7200 individuals. Despite being the most abundant gamefish species in streams of the basin, none of the largemouth bass collected were of legal size (12 inches or larger). Smallmouth bass were the next most abundant gamefish species in basin streams, with a density of 1.4 per stream mile. This species had a basin-wide abundance of about 1000 individuals. Almost 13% of the smallmouth bass collected were of legal size (12 inches or larger). Chain pickerel was the third most abundant fish species in the basin, with an estimated stream density of 1.1 per stream mile. The basin-wide abundance for this species was about 800 individuals. Less than 10% of those individuals were of legal size (14 inches or greater). Densities of rainbow trout and brown trout were well below 1 per stream mile, with basin-wide abundances at about 250 and 300 individuals, respectively. All of the rainbow and brown trout collected by the MBSS were of harvestable size (greater than 6 inches) and were probably the result of hatchery stocking during spring 1997. However, several Montgomery County streams not sampled by the MBSS are known to contain reproducing populations of brown trout.

Why were mostly small bass collected in Potomac Washington Metro basin streams?

Because small streams often provide more shelter against predators than the open waters of big rivers, young bass likely venture into them to avoid being eaten by bigger fish.

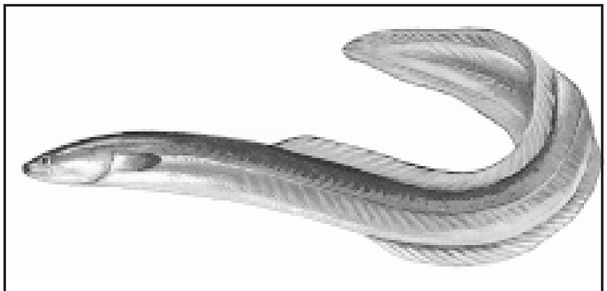
Rare and Uncommon Species

Of the fish species collected during 1994 and 1997 in the Washington Metro basin, no species are presently listed as threatened, rare, or endangered by either the Maryland Department of Natural Resources or the US Fish and Wildlife Service (MDNR 1994).

American eel, sea lamprey and white perch were the only migratory species collected in the basin in 1994 and 1997. Abundance and density estimates were highest for American eel (about 46,000; 67 per stream mile) and lowest for white perch (about 250; 0.3 per stream mile). The abundance and density estimate for sea lamprey was about 2000 individuals, or 3 per stream mile. However, because MBSS fish sampling was conducted from June through September, well after the spawning period of anadromous and semi-anadromous fish, few adults of such species would be expected in the streams sampled.

There are three types of migratory fish in Maryland, anadromous, semi-anadromous, and catadromous. Anadromous species live as adults in estuarine or marine waters, moving into freshwater to spawn. Semi-anadromous species live as adults in estuarine or riverine waters, also moving into freshwater to spawn. However, semi-anadromous species migrate lesser distances. Conversely, catadromous American eels live as adults in freshwater, migrating to marine waters to spawn.

One factor that limits the number of migratory fish within a basin is migration barriers (e.g., dams and culverts). The Potomac Washington Metro basin contains 87 known barriers, and most of the stream miles are upstream from at least one migration barrier. One noteworthy, natural barrier to fish migration is Great Falls on the Potomac River. Although impassable to many fish species, American eels are unique in their ability to leave the water and crawl around this barrier. Although American eels can circumvent most barriers that are impassable to other migratory fish, the majority of migratory fish are forced to use habitat downstream of the lowest migration barrier within the basin and are prevented from moving upstream into smaller streams.



American Eel

Stream Quality Based on Fish Indices of Biotic Integrity

MDNR recently developed a provisional Index of Biotic Integrity (IBI) for non-tidal stream fish communities (Roth et al. 1997) that is an effective tool for evaluating ecological conditions in streams. Using this IBI, various characteristics of the fish community are compared to results from high quality reference streams and scored. The summary score is then used to assess ecological conditions of streams in the basin as Good, Fair, Poor, and Very Poor.

Based on MDNR's fish Index of Biotic Integrity (IBI), about 16% of the stream miles in the Potomac Washington Metro basin were in Good condition, about 27% were in Fair condition, about 12% were categorized as Poor, and 17% of the stream miles in the basin were rated Very Poor (Figure 14). About 28% could not be rated because fish IBIs for very small streams have not yet been developed by MDNR.

Montgomery County Department of Environmental Protection also uses an Index of Biotic Integrity to evaluate ecological conditions in the Potomac Washington Metro basin. Of the 56 sites sampled by Montgomery County in 1997, 23 were rated Good, 26 were rated Fair, 5 were rated Poor, and 2 were rated Very Poor (Figure 14).

Across the basin in 1997, six identical stream reaches (7 site locations within close proximity) were sampled by the MDNR and the Montgomery County DEP. Although MDNR and DEP do not utilize identical methods to evaluate ecological conditions in streams, the results generated for each stream reach were comparable. Of the seven stream site locations, 3 were rated within the same category, whereas 4 differed by only one category. None of the assessments differed by two or more categories.

Prior to human settlement, many small streams in the basin were likely home to brook trout and several other fish species adapted to coldwater conditions. With forest clearing and other human alterations of the landscape, summer stream temperatures increased along with nutrient levels. As a result, brook trout populations have been eliminated from this basin. However, several more tolerant fish species were able to prosper in the now-impaired habitat. Because MDNR's IBI rates streams with high abundance and high diversity more favorably than streams with fewer species and lower numbers of fish (such as trout streams) the current approach may inflate the IBI scores at some sites. Similar to other states that are using fish IBIs to assess water quality and habitat condition in their water bodies (e.g., Ohio and Wisconsin), MDNR is working to develop and apply a separate IBI for fish communities in coldwater streams.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or more simply "benthos", are animals without backbones that are larger than 0.5 millimeter (the size of a pencil dot). These animals live on rocks, logs, sediment, debris, and aquatic plants during some period in their life. The benthos include crustaceans, such as crayfish; mollusks, such as clams and snails; aquatic worms; and the immature forms of aquatic insects, such as stonefly and mayfly nymphs.

Of the approximately 350 genera of stream-dwelling benthic macroinvertebrates in Maryland, more than 40% (153 genera) were found in the Potomac Washington Metro basin. Total number of benthic taxa ranged from 1 to 36 among all sites in the basin. Dominant genera, and their respective percentage occurrence (among all sites in the basin) were: *Cricotopus/Orthocladius* (a non-biting midge; 93%), *Eukiefferiella* (a non-biting midge; 58%), and *Parametriocnemus* (a non-biting midge; 58%). Rare taxa, each found at less than 2% of all sites , included *Perlinella* (a stonefly), *Hydroptila* (a caddisfly) and *Drunella* (a mayfly). A list of all benthic taxa collected in the basin is found in Appendix F.

Stream Quality Based on Benthic Indices of Biotic Integrity

Similar to the fish Index of Biotic Integrity described earlier, MDNR has developed a benthic macroinvertebrate IBI for Maryland streams. The IBI

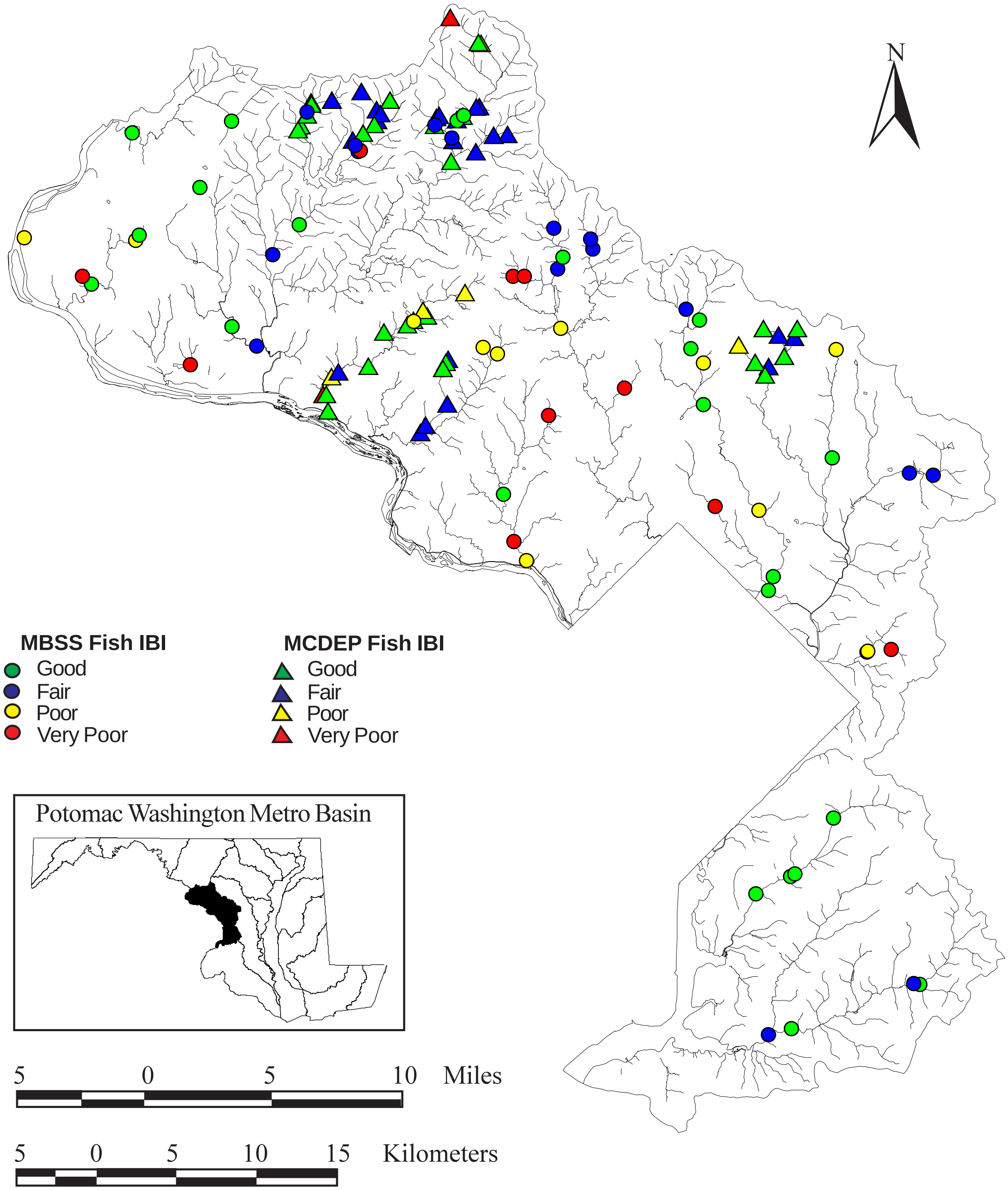


Figure 14. Stream ecological condition in the Potomac Washington Metro basin (1997) based on the fish Index of Biotic Integrity (IBI) for both the MBSS and Montgomery County DEP.

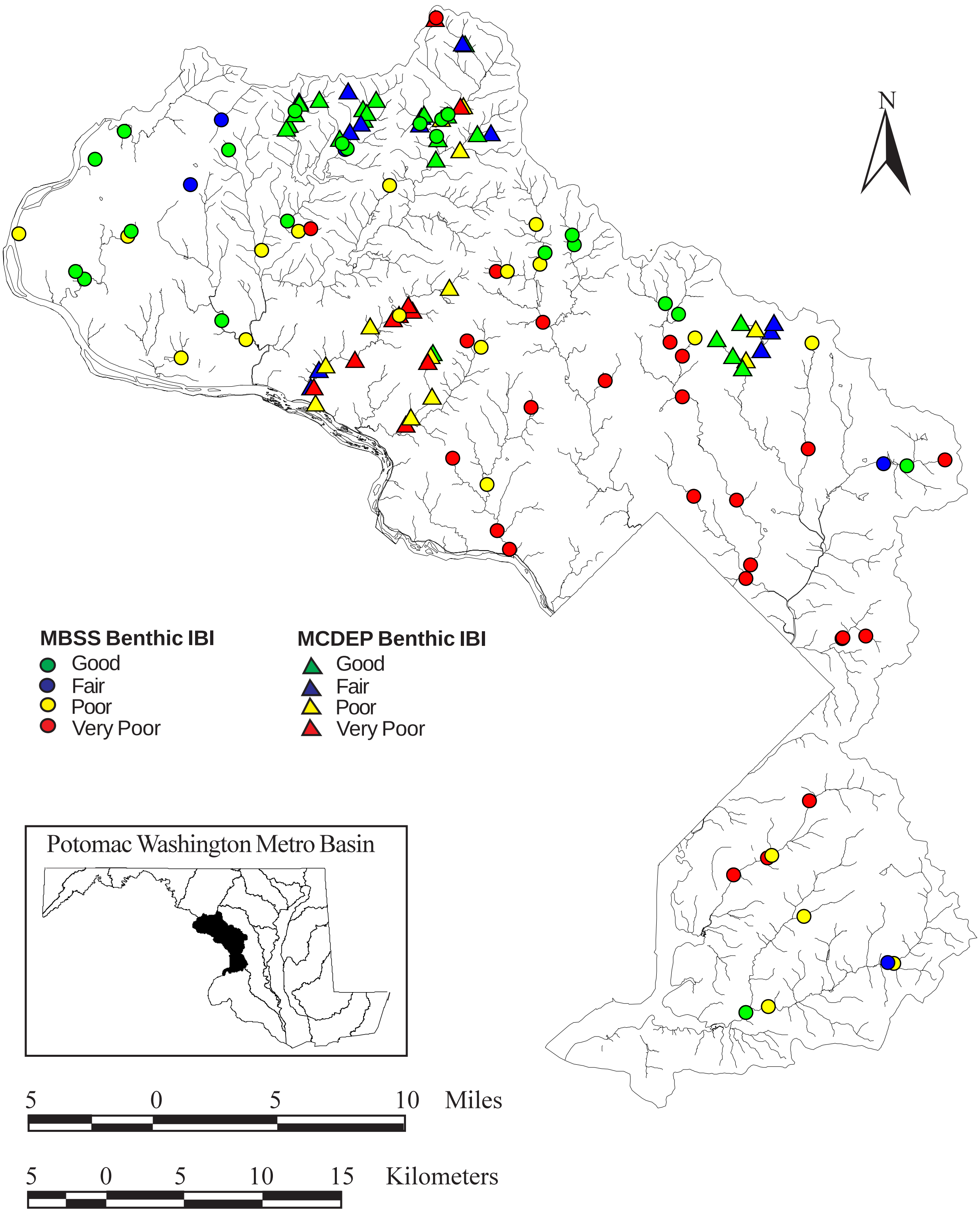


Figure 15. Stream ecological condition in the Potomac Washington Metro basin (1997) based on the benthic Index of Biotic Integrity (IBI) for both the MBSS and Montgomery County DEP.

used in the Potomac Washington Metro basin includes several metrics that measure taxa richness, pollution sensitivity, feeding modes, and habit. The IBI scores range from 1 (worst) to 5 (best).

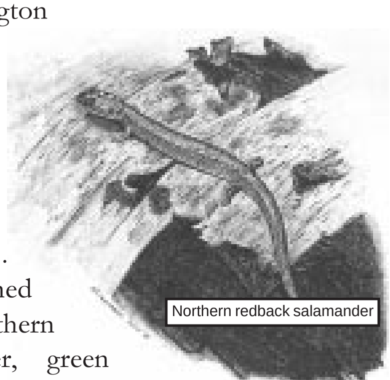
In the Potomac Washington Metro basin, the benthic IBI ranged from 1.0 (Very Poor) to 4.8 (Good) among all sites. About 8% of all stream miles were rated as Good, 27% were rated as Fair, 29% were rated as Poor, and 36% were rated as Very Poor (Figure 15).

In addition to having an IBI based on the fish community, Montgomery County DEP also has a benthic macroinvertebrate IBI. Of the 56 sites sampled by Montgomery County in 1997, 13 were rated in Good condition, 21 were rated in Fair condition, 12 were rated in Poor condition, and 10 were rated in Very Poor condition (Figure 15).

Across the basin in 1997, seven identical stream reaches (8 site locations within close proximity) were sampled by the MDNR and the Montgomery County DEP. Although slightly different methods for assessment were utilized, results were again comparable. Of the 8 stream site locations sampled, 5 were rated within the same category, whereas as 3 differed by only one category. None of the assessments for each stream reach differed by two or more categories.

REPTILES AND AMPHIBIANS

Reptiles and/or amphibians were found at approximately 90% of the sites sampled in the Potomac Washington Metro basin in 1994 and 1997. Nine frog, 4 turtle, 5 salamander, 5 snake and 1 lizard species were observed (Table 2). Northern two-lined salamander, Northern dusky salamander, green frog, bullfrog, and Northern water snake were the most common species, occurring at 44%, 37%, 34%, 24%, and 11% of the sites, respectively (Figure 16).



Northern redback salamander

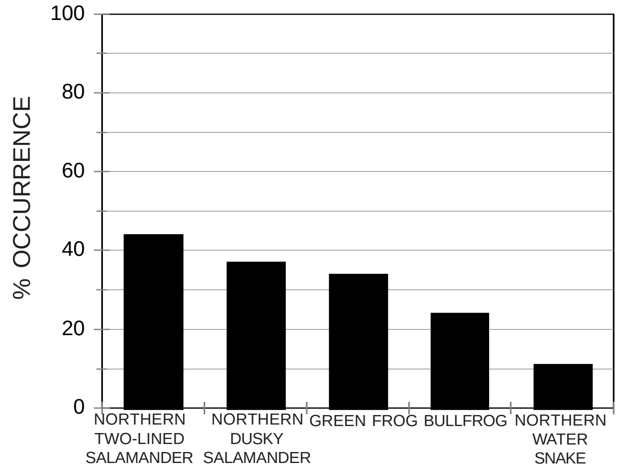


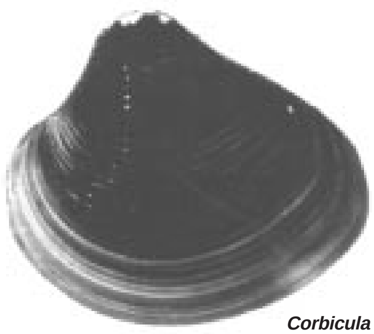
Figure 16. Percent occurrence of the five most commonly observed amphibians and reptiles at streams sampled in the Washington Metro basin in 1994 and 1997.

Table 2. List of herpetofauna observed in the Potomac Washington Metro basin in 1994 and 1997.

Common Name	***Scientific Name***
Frogs and Toads	
Northern Spring Peeper	*Pseudacris crucifer crucifer*
Southern Leopard Frog	*Rana utricularia*
Pickerel Frog	*Rana palustris*
Northern Leopard Frog	*Rana pipiens*
Wood Frog	*Rana sylvatica*
Bullfrog	*Rana catesbeiana*
Green Frog	*Rana clamitans melanota*
Fowler's Toad	*Bufo woodhousii fowleri*
American Toad	*Bufo americanus*
Turtles	
Spotted Turtle	*Clemmys guttata*
Eastern Painted Turtle	*Chrysemys picta picta*
Common Snapping Turtle	*Chelydra serpentina serpentina*
Eastern Box Turtle	*Terrapene carolina carolina*
Salamanders	
Redback Salamander	*Plethodon cinereus*
Eastern Mud Salamander	*Pseudotriton montanus montanus*
Red Salamander	*Pseudotriton ruber*
Northern Dusky Salamander	*Desmognathus fuscus fuscus*
Northern Two - Lined Salamander	*Eurycea bislineata*
Snakes	
Queen Snake	*Regina septemvittata*
Northern Ringneck Snake	*Diadophis punctatus edwardsii*
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*
Black Rat Snake	*Elaphe obsoleta obsoleta*
Northern Water Snake	*Nerodia sipedon sipedon*
Lizards	
Five-Lined Skink	*Eumeces fasciatus*

FRESHWATER MUSSELS

Freshwater mussels were collected at 4 (6%) of the random stream sites sampled in the Potomac Washington Metro basin in 1997. The only species collected was the Asiatic clam (*Corbicula fluminea*), an introduced species that has spread rapidly throughout the 20th century.



Corbicula fluminea

CHAPTER FIVE
SUMMARY OF STREAM RESOURCE CONDITIONS

Information from the Maryland Biological Stream Survey in 1997 has provided us with a snapshot of living resources, stream conditions, and major stressors to the aquatic habitat in the Potomac Washington Metro basin. Like most Maryland watersheds, the basin consists of a network of streams that range in quality from extremely degraded to relatively healthy. MBSS' one-time measurements of dissolved oxygen, pH, and acid neutralizing capacity indicate that most streams have acceptable levels of water quality and no violations of state water quality standards. However, elevated nitrate-nitrogen levels were extremely common throughout the basin (>80% of all stream miles) and clearly related to the proportion of land in agriculture or urbanization upstream from sample sites (Figure 17; next page).

Considering the fact that MBSS sampling is conducted under baseflow conditions, groundwater is a chronic, large-scale source of nitrogen in the basin. Because of its area and elevated nitrogen levels, the basin is an important source of nutrients to the Potomac River and eventually Chesapeake Bay. With elevated nutrient conditions so widespread, reducing nutrients in a few of the worst streams is unlikely to correct the problem, instead a general reduction of nitrogen loading throughout the basin will be necessary.

Although most streams met state water quality standards based on the MBSS data (a common result from other surveys which measure only water chemistry), the living resources in the basin clearly indicate that environmental problems do exist. Based on MDNR's fish Index of Biotic Integrity, only 16% of the stream miles assessed were Good, while 30% of the stream miles assessed were in Poor or Very Poor condition. The benthos indicated even larger problems, with 65% of all streams in Poor or Very Poor condition based on the benthic IBI. Benthic IBI scores generally decrease as the amount of impervious surface increases within a watershed (Figure 18) (The amount of impervious surface was estimated using USDA 1986). Overall, both fish and benthos indicate substantial problems with stream resources exist in the basin. These problems appear to be directly related to the amount of urbanization in this watershed. The basin has the highest percentage of urban land use (45% or approximately 192 square miles of the basin) of all 18 major river basins in the state.

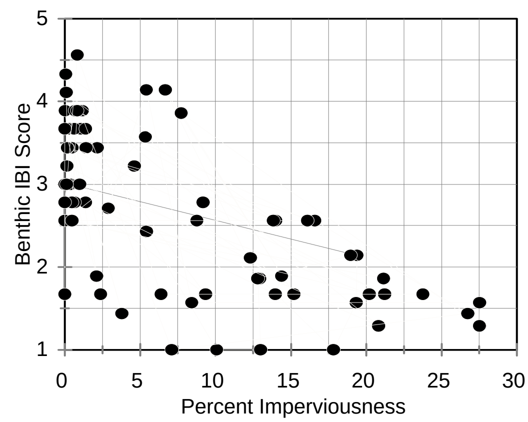


Figure 18. Impervious surface and benthic IBI at MBSS stream sites in the Potomac Washington Metro basin (1997).

Although 18% of the stream miles in the basin appear to be in Good condition based on physical habitat, almost 30% of the stream miles are degraded. The major reasons for this degradation include a lack of rootwads and woody debris in the stream channel from historical and ongoing logging practices, excess silt and unstable stream banks from land use changes, modification of stream channels because of increased runoff and channelization, and loss of functional (vegetated with no direct runoff sources, e.g., storm drainage) riparian buffer zones. Large woody debris and rootwads function to reduce the erosive power of water. Without these natural structures, the problem of bank instability intensifies. Over 20% of all stream miles in the Potomac Washington Metro basin have unstable or moderately unstable stream banks. One major problem associated with unstable bank

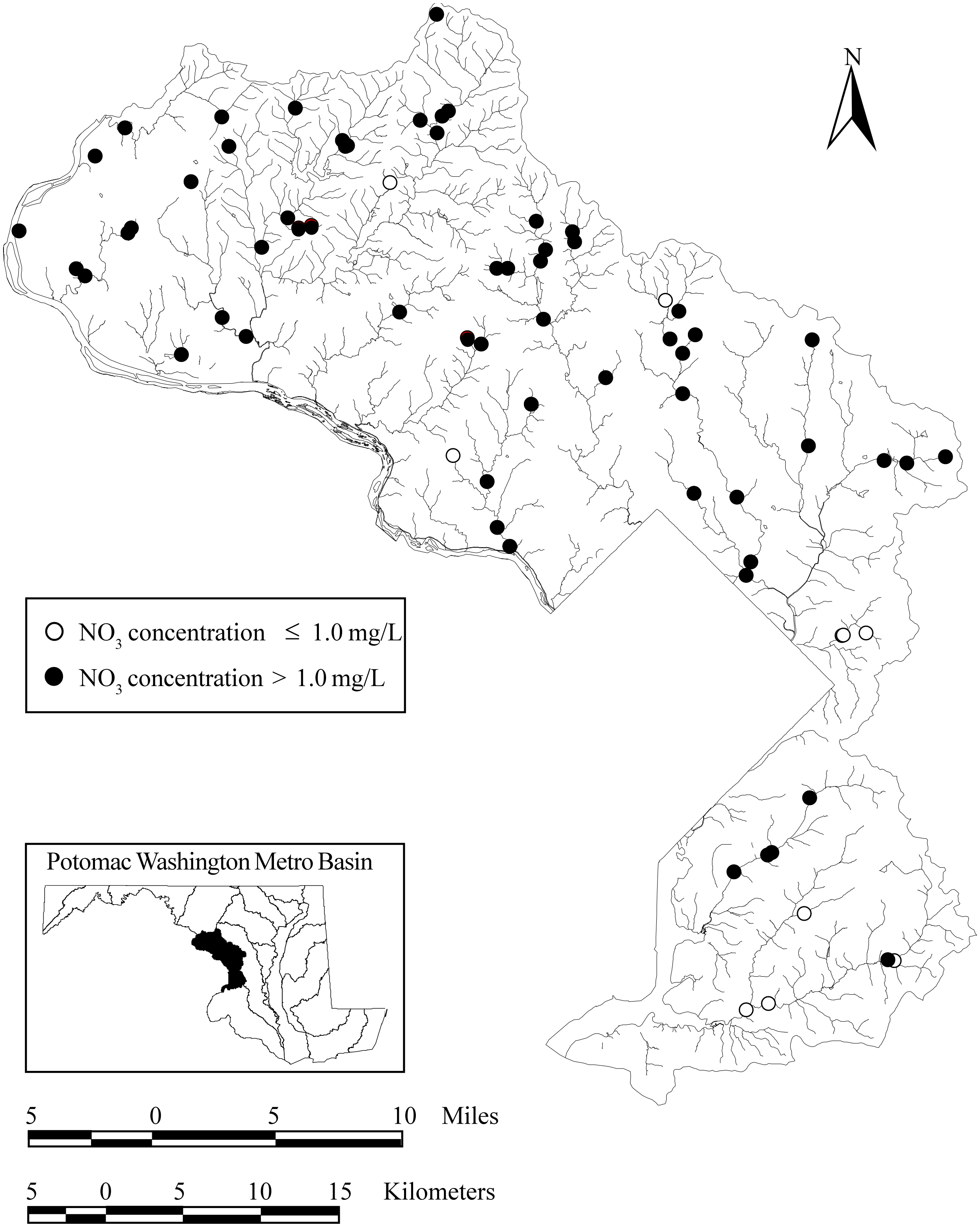


Figure 17. Nitrate-nitrogen concentrations in the Potomac Washington Metro basin in 1997.

conditions is an increase in the amount of silt that enters the stream. Increased silt smothers rocks and gravel, reducing habitat available for benthos and food supplies for fish. The problem of bank erosion is further compounded in streams that experience increased runoff due to land use changes that increase the amount of impervious surface, a major problem in the Potomac Washington Metro basin. Lastly, 28% of the streams in the basin are rated as having no functional (vegetated with no direct runoff sources, e.g., storm drainage) riparian buffer, reducing the ecological integrity of the stream and threatening downstream areas as well. This lack of protective vegetation along streams is an obvious starting point in the restoration process because riparian buffers improve both water quality and physical habitat in several ways. In general, the results of the MBSS clearly indicate that physical habitat degradation is an important widespread problem in the Potomac Washington Metro basin.

The fish community in non-tidal streams of the basin is diverse. Thirteen of the 61 species of fish collected are non-native, and most, if not all, of these species were introduced by fishery managers or anglers. From a recreational aspect, some of these introductions have been beneficial, but ecological impacts (such as the reduction in distribution and abundance of native species) have occurred and will continue. Unfortunately, there is little historical information about fish communities in the streams of the basin. Therefore, it is difficult to determine if the introduction of non-native fishes has influenced the distribution and abundance of native species. The MBSS results establish a useful benchmark of current fish species composition, distribution, and abundance that can be used to track future changes. Because of the recognized potential for detrimental effects, the Chesapeake Bay states have started a review process for proposed introductions of non-native species that should reduce the number of unwise introductions.

Five species of gamefish were present in the Potomac Washington Metro basin. Only chain pickerel is native to the basin; the rest have been introduced by fisheries managers. Largemouth bass and smallmouth bass are the most abundant gamefish. However, in first, second, and third-order streams, most of the individuals are smaller than the legal size limit. Chain pickerel are the third most abundant gamefish species, with approximately 1 per stream mile. Although rainbow trout and brown trout are uncommon, most are of harvestable size. Because the four introduced species are top predators in the fish community, changes in fish community composition have likely occurred, but are not documented.

American eel, white perch and sea lamprey are the three migratory species that were documented in the basin by the MBSS during 1994 and 1997. Of these, the American eel is the most abundant species. The Potomac Washington Metro basin has 87 known barriers to anadromous fish movement (Figure 19). The prevalent type of blockages are dams (38%) and the majority are found on tributary streams. However, there are large impediments to fish migration on the Potomac River. One natural barrier is Great Falls, a 76 foot waterfall approximately 15 miles upstream from the Nation's capital. With future expansion of housing and other development in this rapidly growing basin, the number of barriers (e.g., pipe crossings and culverts) will likely increase as more roads and sewage systems are constructed, thus reducing the amount of habitat accessible to migratory fish.

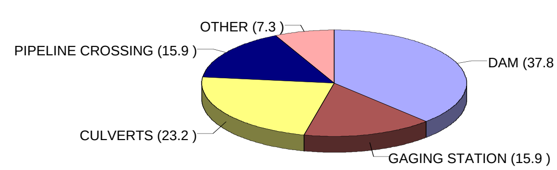


Figure 19. Barriers to fish migration in the Potomac Washington Metro basin (percentages).

The amount of rain and snow falling onto a watershed is an important factor in shaping the biological community of a stream. Dry, low flow periods are considered stressful for stream life due to higher water temperatures, low dissolved oxygen levels, and reduction in the amount of available habitat. Conversely, extremely heavy rainfall and high flows from increased watershed imperviousness may result in large-scale changes in physical habitat, temporarily lethal water quality conditions, mortality of bottom species because of crushing by moving rocks, and transport of aquatic animals to less favorable habitat.

In 1997, total rainfall in the Potomac Washington Metro basin was about 16% lower than average (Figure 20)(NOAA 1997). Only 2 months, March and November, had above average rainfall. July and September were the driest months. Extremely dry periods during summer baseflow may have caused significant stress to stream biota in the basin. The end result may be reductions in species richness and abundance of fish and benthic macroinvertebrates. Without long-term data on rainfall, flow, and stream ecological conditions, it is difficult to determine relationships among these environmental factors and stream quality. When the MBSS is repeated in future years, more light should be shed on this important subject.

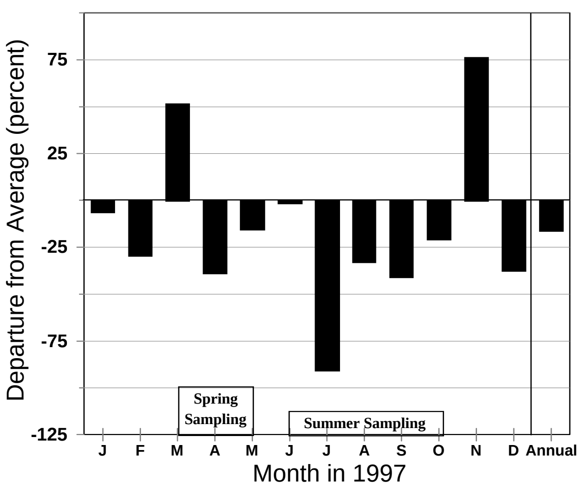


Figure 20. Monthly rainfall in the Potomac Washington Metro basin in 1997. Bars indicate departure, as percent, from average monthly rainfall amounts for the period of 1961-1990. Annual rainfall departures shown at right. The spring and summer sampling periods are also shown.

Given the level and types of stream impacts noted in 1997 and the projected changes in land use, human population size, and water demands in the Potomac Washington Metro basin, the biological communities and other ecological attributes of streams in the basin will likely become more degraded in years to come. Comprehensive implementation of best management practices (BMPs), such as riparian zone protection and reforestation, may partially offset these impacts. It is important to note that BMPs may reduce, but do not eliminate, the ecological impacts of human disturbance.

This report clearly illustrates that some valuable stream resources still exist in the basin. However, in many ways the basin still suffers from mistakes of the past. The entire basin has been logged, including riparian zones. As a result, unstable stream channels are common, physical habitat is greatly reduced, and even forested streams now carry elevated sediment loads. In addition, a network of dams and other migration barriers excludes many fish species from usable stream habitat. In more urbanized areas of the basin, large volumes of water flush directly into streams during storms and baseflows are reduced to a trickle during dry periods. These extreme fluctuations in flow create conditions that only the hardiest of aquatic animals can tolerate. All of these problems can be lessened or eliminated, but great cost is typically involved. Over time, we must work to restore conditions in the basin for future generations. At the same time, however, we also need to make a concerted effort to protect and enhance the remaining high quality resources in the basin and elsewhere in Maryland. Only in this way can we learn to exist in a sustainable manner.

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SYNOPSIS OF MBSS DESIGN AND SAMPLING METHODS

The MBSS is intended to provide unbiased estimates of the condition of streams and rivers of Maryland on a local (e.g., drainage basin or county) as well as a statewide scale. To date, the MBSS has focused on wadeable, headwater streams. The survey is based on a probabilistic stream sampling approach where random selections are made from all sections of streams in the state which can physically be sampled. The approach supports statistically-valid population estimation of variables of interest (e.g., largemouth bass densities, miles of streams with degraded physical habitat, etc.). When repeated, the MBSS will also provide a basis for assessing future changes in ecological condition of flowing waters of the state. At present, plans are to continue the MBSS and develop a quantitative sampling approach for larger streams and rivers.

The study area for the MBSS includes each of the 18 major drainage basins of the state, and a total of three years was required to sample all 18 basins. For logistical reasons, the state was divided into three geographic regions (east, west, and central) with five to seven basins in each region. Each basin was sampled at least once during the three year cycle, and one basin in each region was sampled twice so that data collected in different years could be combined into a single statewide estimate for each of the variables of interest.

The sampling frame for the MBSS was constructed by overlaying basin boundaries on a map of all blueline stream reaches in the state as digitized on a U.S. Geological Survey 1:250,000 scale map. Sampling within basins was restricted to non-tidal, first, second and third-order (Strahler 1964) stream reaches, excluding unwadeable or otherwise unsampleable areas. An additional restriction was that only public land or privately-owned sites where landowner permissions was obtained were sampled.

During 1995 the MBSS sample sites were selected from a comprehensive list of headwater stream reaches in 6 of the 18 drainage basins. In 1996 sample sites were selected from 7 of the drainage basins, and in 1997 the remaining basins were sampled. To provide adequate information about each size of stream, an approximately equal number of first, second and third order streams was sampled during spring and summer, with the number of sites of each order in a basin being proportional to the number of stream miles (of an order) in the entire state.

Benthic macroinvertebrates and water quality samples were collected during the spring index period from March through early May, while fish, herpetofauna, *in situ* stream chemistry and physical habitat sampling were conducted during the low flow period in the summer, from June through September.

In the spring, water samples were collected and analyzed for pH, acid-neutralizing capacity (ANC), sulfate (SO_4), nitrate (NO_3), conductivity, and dissolved organic carbon (DOC) in the laboratory. These variables primarily characterize the sensitivity of the streams to acid deposition, and to other anthropogenic stressors to a lesser extent. Benthic macroinvertebrates collected in the spring were identified to family and genus level in the laboratory.

Habitat assessments were conducted in the summer using metrics largely patterned after EPA's Rapid Bioassessment Protocols and Ohio EPA's Qualitative Habitat Evaluation Index (QHEI) described by Rankin (1989), Plafkin *et al.* (1989), and Platts *et al.* (1983) in the designated 75 m length of the stream segments; riparian habitat measurements were based on the surrounding area within 20 m of the segment. Other qualitative measurements included (1) aesthetic value, based on evidence of human refuse; (2) remoteness, based on the absence of detectable human activity and difficulty in accessing the segment; (3) land use, based on the surrounding area immediately visible from the segment; (4) general stream character, based on the shape, substrate, and vegetation of the segment; and (5) bank erosion, based on the kind and extent of erosion present. Quantitative measurements at each segment included flow, depth, wetted width, and stream gradient.

Fish and herpetofauna were sampled during the summer index period using quantitative, double-pass electrofishing of the 75 m stream segments. Blocking nets were placed at each end of the segment, and one or more direct-current, backpack electrofishing units were used to sample the entire segment. All fish captured during each electrofishing pass were identified, counted, weighed in aggregate, and up to 100 individuals of each species were examined for external anomalies such as lesions and tumors. All gamefish captured were also measured for length. Any amphibians, reptiles, freshwater molluscs, submerged aquatic vegetation either in or near the stream segment were collected and identified.

For all phases of the MBSS, there was a ongoing, documented program of quality assurance/quality control (QA/QC). The QA/QC program used by the MBSS allows for generation of data with known confidence.

STREAMS SAMPLED IN THE POTOMAC WASHINGTON METRO BASIN IN 1997 AS PART OF THE MARYLAND BIOLOGICAL STREAM SURVEY (MBSS) (QUANTITATIVE SAMPLES ONLY)

As described in Chapter 3 and Appendix B, MBSS sampling sites were selected randomly from 1:250,000 scale maps. Many very small streams were selected--some with names and some without. Stream names were acquired for the MBSS database from several map sources. Those streams with no names are called unnamed tributaries. Many streams in Maryland share the same name. For example, in addition to the Beaverdam Creek sampled by MBSS in the Potomac Washington Metro basin, there are 6 other Beaverdam Creeks in Maryland. Statewide, there are also 6 Broad Runs and 2 Cabin John Creeks.

Beaverdam Creek (5 sites)
Beaverdam Creek Unnamed Tributary
Broad Run (4 sites)
Bucklodge Branch
Cabin John Creek (3 sites)
Cabin John Creek Unnamed Tributary (2 sites)
Dry Seneca Creek (3 sites)
Great Seneca Creek (3 sites)
Gunners Branch
Henson Creek (4 sites)
Little Monocacy River
Little Monocacy River Unnamed Tributary
Little Paint Branch (2 sites)
Little Seneca Creek (2 sites)
Little Seneca Creek Unnamed Tributary
Magruder Branch
Mill Creek
Mill Creek Unnamed Tributary
Muddy Branch
North Branch Rock Creek (2 sites)
Northwest Branch (6 sites)
Northwest Branch Anacostia River
Northwest Branch Unnamed Tributary (2 sites)
Piscataway Creek (3 sites)
Piscataway Creek Unnamed Tributary (2 sites)
Potomac River Unnamed Tributary (3 sites)
Rock Creek (3 sites)
Rock Creek Unnamed Tributary (2 sites)
Seneca Creek
Seneca Creek Unnamed Tributary (3 sites)
Sligo Creek
Ten Mile Creek
Watts Branch
Watts Branch Unnamed Tributary
Wild Cat Branch

Location and water quality data for 1997 Maryland Biological Stream Survey sites in the Potomac Washington Metro basin. Temperature (^oC) and dissolved oxygen (DO) were measured in the summer while all other parameters were measured during spring. Units of measure for DO, nitrate nitrogen (NO_3), sulfate (SO_4) and dissolved organic carbon (DOC) are mg/L, while the units of measure for acid neutralizing capacity (ANC) are *u*eq/L. * = no data, UT = Unnamed Tributary

Stream Name	*Latitude*	*Longitude*	*^oC*	*DO*	*pH*	*ANC*	*NO_3*	*SO_4*	*DOC*
BEAVERDAM CREEK	39.0210000	76.8560000	17.8	7.9	6.69	209.00	1.525	16.038	4.0
BEAVERDAM CREEK	39.0230000	76.8730000	21.0	8.5	6.71	210.50	1.145	15.555	4.1
BEAVERDAM CREEK	38.9210000	76.9040000	20.0	7.5	7.30	1341.10	0.966	30.965	4.5
BEAVERDAM CREEK	38.9220000	76.9030000	20.0	7.5	7.56	1318.80	0.167	31.498	3.8
BEAVERDAM CREEK	39.0249972	76.8270000	15.0	7.8	5.91	182.00	4.708	18.701	1.8
BROAD RUN	39.1540000	77.4350000	18.9	8.0	7.15	515.60	1.760	16.632	6.1
BROAD RUN	39.1290000	77.4670000	19.1	7.3	7.48	624.30	2.451	18.173	2.6
BROAD RUN	39.1330000	77.4740000	20.0	9.8	6.76	199.00	2.548	6.776	1.5
BROAD RUN	39.1570000	77.4330000	21.5	7.6	7.10	481.60	1.831	16.616	6.1
BUCKLODGE BRANCH	39.2040000	77.3610000	15.0	9.3	6.86	446.50	4.097	10.706	3.7
CABIN JOHN CREEK	39.0099972	77.1680000	15.0	8.2	7.65	1083.40	1.565	16.087	1.7
CABIN JOHN CREEK	38.9730000	77.1510000	15.0	9.8	8.09	1347.00	1.730	19.718	1.9
CABIN JOHN CREEK	38.9840000	77.1599972	19.5	9.1	7.83	1200.70	1.788	18.179	1.9
DRY SENECA CREEK	39.0940000	77.3470000	22.6	10.7	7.95	711.40	2.474	15.707	2.2
DRY SENECA CREEK	39.1049972	77.3649972	26.0	9.2	8.26	703.30	2.368	14.790	2.5
DRY SENECA CREEK	39.1840000	77.3890000	18.0	6.8	6.97	504.10	1.631	9.255	7.4
GREAT SENECA CREEK	39.2250000	77.1970000	22.0	6.7	7.28	481.60	3.370	7.594	1.2
GREAT SENECA CREEK	39.2220000	77.2020000	21.3	8.6	7.44	488.50	3.371	7.508	1.3
GREAT SENECA CREEK	39.2120000	77.2060000	19.9	7.7	7.33	466.20	3.614	6.865	1.3
GUNNERS BRANCH	39.1840000	77.2410000	15.0	10.5	7.47	1097.90	0.304	7.547	1.5
HENSON CREEK	38.8270000	76.9280000	23.0	7.0	7.36	765.30	1.072	24.320	3.4
HENSON CREEK	38.7840000	76.9849972	17.0	8.6	7.44	837.80	4.588	14.933	3.0
HENSON CREEK	38.7940000	76.9599972	19.0	9.4	7.44	758.20	1.118	26.122	3.0
HENSON CREEK	38.7960000	76.9560000	19.0	9.4	7.35	713.70	1.152	26.858	3.1
LITTLE MONOCACY R.	39.2150000	77.4380000	20.0	8.9	7.28	608.80	1.825	9.811	4.0
LITTLE PAINT BRANCH	39.0930000	76.9260000	19.9	8.8	7.24	483.10	1.212	8.771	2.1
LITTLE PAINT BRANCH	39.0310000	76.9290000	17.5	9.4	7.64	592.30	1.192	12.269	2.3
LITTLE SENECA CREEK	39.2049972	77.2740000	19.0	8.1	7.22	426.70	3.790	6.156	2.1
LITTLE SENECA CREEK	39.2049972	77.2720000	19.0	8.1	7.23	415.40	3.790	6.161	1.8
MAGRUDER BRANCH	39.2810000	77.2060000	17.6	6.0	7.54	1357.90	2.617	18.856	0.8
MILL CREEK	39.1340000	77.1530000	13.1	8.3	7.48	1447.00	1.706	15.771	2.4
MUDDY BRANCH	39.1080000	77.2330000	17.0	8.9	7.47	976.50	2.052	12.768	2.6
N. BRANCH ROCK CREEK	39.1550000	77.1050000	17.8	9.1	7.09	377.50	1.688	5.795	3.3
N. BRANCH ROCK CREEK	39.1490000	77.1030000	12.0	9.3	7.14	389.70	1.878	5.965	3.2
NORTHWEST BRANCH	39.0620000	77.0230000	16.5	9.6	7.75	845.50	1.530	13.316	1.9
NORTHWEST BRANCH	39.1090000	77.0260000	22.0	7.6	7.26	630.50	1.944	10.359	3.5
NORTHWEST BRANCH	39.0930000	77.0320000	17.5	8.9	7.32	827.60	1.572	13.383	3.8
NORTHWEST BRANCH	39.0850000	77.0230000	20.8	8.2	7.31	810.40	1.564	13.224	3.8
NORTHWEST BRANCH	39.0010000	76.9820000	23.0	6.9	7.48	889.50	1.680	13.978	1.9
NORTHWEST BRANCH	38.9560000	76.9749972	25.0	6.5	7.63	1058.90	1.636	17.292	2.4
NW BRANCH ANACOSTIA R.	38.9640000	76.9720000	23.0	8.4	7.72	883.50	1.410	14.445	1.9
PISCATAWAY CREEK	38.7049972	76.9749972	25.6	5.6	6.97	304.00	0.710	22.855	2.7
PISCATAWAY CREEK	38.7330000	76.8710000	21.0	6.7	6.92	320.20	1.008	21.870	3.8
PISCATAWAY CREEK	38.7080000	76.9590000	21.2	6.7	7.02	214.30	0.721	22.191	2.8
ROCK CREEK	39.1049972	77.1260000	26.9	6.8	7.35	621.90	1.730	8.390	3.7

Stream Name	Latitude	Longitude	°C	DO	pH	ANC	NO_3	SO_4	DOC
ROCK CREEK	39.1380000	77.1290000	17.5	9.7	7.17	414.00	2.662	7.892	1.7
ROCK CREEK	39.1450000	77.1250000	19.0	7.9	7.12	401.90	2.754	7.760	2.0
SENECA CREEK	39.1460000	77.3360000	20.1	9.9	7.30	564.70	1.577	8.373	3.0
SLIGO CREEK	39.0040000	77.0140000	18.8	7.5	8.22	1380.70	2.353	17.353	2.5
TEN MILE CREEK	39.2270000	77.3110000	18.0	7.8	7.32	493.40	1.360	9.811	2.0
UT TO BEAVERDAM CREEK	38.9230000	76.8860000	22.5	5.8	7.25	1226.30	0.813	38.605	4.0
UT TO CABIN JOHN CREEK	39.0549972	77.1350000	14.5	9.3	7.42	1339.50	1.986	19.514	2.9
UT TO CABIN JOHN CREEK	39.0260000	77.1930000	20.5	7.8	7.72	1884.90	0.632	33.133	3.2
UT TO LITTLE MONOCACY	39.2210000	77.3660000	18.0	7.9	6.93	385.70	1.512	5.614	3.1
UT TO LITTLE SENECA CR.	39.2080000	77.2760000	19.0	8.3	7.02	405.90	2.158	7.340	1.7
UT TO MILL CREEK	39.1340000	77.1610000	18.1	8.6	7.30	797.40	1.826	10.411	1.7
UT TO NORTHWEST BR.	39.0960000	77.0130000	14.0	9.9	7.22	852.10	2.130	11.346	1.9
UT TO NORTHWEST BR.	39.1160000	77.0349972	22.3	6.8	7.31	845.40	0.980	13.052	3.4
UT TO PISCATAWAY CREEK	38.7599972	76.9320000	*	*	6.85	345.50	0.948	19.906	3.1
UT TO PISCATAWAY CREEK	38.7330000	76.8660000	26.5	6.4	6.75	278.10	0.596	19.852	3.0
UT TO POTOMAC R.	39.1550000	77.5170000	25.0	5.5	7.32	496.90	1.310	9.037	2.8
UT TO POTOMAC R.	39.0830000	77.3949972	13.9	6.4	7.25	1156.10	1.454	25.166	3.5
UT TO POTOMAC R.	39.1980000	77.4599972	15.0	8.0	7.20	1687.20	1.324	39.935	20.6
UT TO ROCK CREEK	39.0710000	77.0799972	15.0	8.8	7.63	2299.90	1.533	40.040	2.3
UT TO ROCK CREEK	39.1610000	77.1320000	18.0	6.8	6.92	395.00	2.466	7.608	2.5
UT TO SENECA CREEK	39.1590000	77.2990000	21.0	9.1	6.91	337.30	5.514	6.617	2.3
UT TO SENECA CREEK	39.1630000	77.3170000	19.0	9.4	7.29	429.40	4.334	7.388	3.0
UT TO SENECA CREEK	39.1570000	77.3080000	21.0	9.2	6.68	273.80	5.363	6.066	1.9
UT TO WATTS BRANCH	39.0940000	77.1830000	26.5	6.7	7.45	894.70	5.248	14.191	3.3
WATTS BRANCH	39.0900000	77.1720000	13.0	9.3	7.61	811.40	4.054	13.520	2.6
WILD CAT BRANCH	39.2199972	77.2180000	17.4	8.4	7.16	266.20	4.720	5.005	0.6

PHYSICAL HABITAT CONDITIONS MEASURED BY MBSS

I. SUBSTRATE AND INSTREAM COVER

Instream Habitat is rated according to the perceived value of habitat to the fish community. Higher scores are assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores are assigned to sites with a high degree of uneven substrate. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

Epifaunal Substrate is rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, flocculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.

Velocity/Depth Diversity is rated based on the variety of velocity/depth regimes present at a site (slow-shallow, slow-deep, fast-shallow, and fast-deep). As with embeddedness, this metric may result in lower scores in low-gradient streams but will provide statewide information on the physical habitat found in Maryland streams.

Pool/Glide/Eddy Quality is rated based on the variety and spatial complexity of slow or still water habitat within the sample segment. In high-gradient streams, functionally important slow water habitat may exist in the form of larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris or other types of cover for fish.

Riffle/Run Quality is based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

Embeddedness is a percentage of surface area of larger particles that is surrounded by fine sediments on the stream bottom. In low gradient streams, embeddedness may be high even in unimpaired streams.

II. CHANNEL CHARACTER

Channel Alteration is a measure of large-scale changes in the shape of the stream channel. Channel alteration includes: concrete channels, artificial embankments, obvious straightening of the natural channel, rip-rap, or other structures, as well as recent bar development. Ratings for this metric are based on the presence of artificial structures as well as the existence, extent, and coarseness of point bars, side bars, and mid-channel bars which indicate the degree of flow fluctuations and substrate stability. Evidence of channelization may sometimes be seen in the form of berms which parallel the stream channel.

Bank Stability is rated based on the presence/absence of riparian vegetation and other stabilizing bank materials such as boulders and rootwads, and frequency/size of erosional areas. Sites with steep slopes are not penalized if banks are composed solely of stable materials.

Channel Flow Status is the percentage of the stream channel that has water, with subtractions made for exposed substrates and dewatered areas.

III. RIPARIAN CORRIDOR

Shading is rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by land forms.

Riparian Buffer is rated according to the size and type of the vegetated riparian buffer zone at the site. Cultivated fields for agriculture which have bare soil to any extent are not considered as riparian buffers. At sites where the buffer width is variable or direct delivery of storm runoff or sediment to the stream is evident or highly likely, the narrowest representative buffer width in the segment (e.g., 0 if parking lot runoff enters directly to the stream) is measured and recorded even though some of the stream segment may have a well developed riparian buffer.

IV. AESTHETICS/REMOTENESS

Aesthetics are rated according to the visual appeal of the site and presence/absence of human refuse, with highest scores assigned to stream segments with no human refuse and visually outstanding character.

Remoteness is rated based on the absence of detectable human activity and difficulty in accessing the segment.

MBSS Habitat Assessment Guidance Sheet

Habitat Parameter	Optimal 16-20	Sub-Optimal 11-15	Marginal 6-10	Poor 0-5
1. Instream Habitat[a]	Greater than 50% mix of a variety of cobble, boulder, submerged logs, undercut banks, snags, rootwads, aquatic plants, or other stable habitat	30-50% mix of stable habitat. Adequate habitat	10-30% mix of stable habitat. Habitat availability less than desirable	Less than 10% stable habitat. Lack of habitat is obvious
2. Epifaunal Substrate[b]	Preferred substrate abundant, stable, and at full colonization potential (riffles well developed and dominated by cobble; and/or woody debris prevalent, not new, and not transient)	Abund. of cobble with gravel &/or boulders common; or woody debris, aquatic veg., under-cut banks, or other pro-ductive surfaces common but not prevalent /suited for full colonization	Large boulders and/or bedrock prevalent; cobble, woody debris, or other preferred surfaces uncommon	Stable substrate lacking; or particles are over 75% surrounded by fine sediment or flocculent material
3. Velocity/Depth Diversity[c]	Slow (<0.3 m/s), deep (>0.5 m); slow, shallow (<0.5 m); fast (>0.3 m/s), deep; fast, shallow habitats all present	Only 3 of the 4 habitat categories present	Only 2 of the 4 habitat categories present	Dominated by 1 velocity/depth category (usually pools)
4. Pool/Glide/Eddy Quality[d]	>50% pool/glide/eddy habitat; both deep (>.5 m)/shallows (<.2 m) present; complex cover/&/or depth >1.5 m	10-50% pool/glide/eddy habitat, with deep (>0.5 m) areas present; or >50% slow water with little cover	<10% pool/glide/eddy habitat, with shallows (<0.2 m) prevalent; slow water areas with little cover	Pool/glide/eddy habitat minimal, with max depth <0.2 m, or absent completely
5. Riffle Quality[e]	Riffle/run depth generally >10 cm, with maximum depth greater than 50 cm (maximum score); substrate stable (e.g. cobble, boulder) & variety of current velocities	Riffle/run depth generally 5-10 cm, variety of current velocities	Riffle/run depth generally 1-5 cm; primarily a single current velocity	Riffle/run depth < 1 cm; or riffle/run substrates concreted
6. Channel Alteration[f]	Little or no enlargement of islands or point bars; no evidence of channel straightening or dredging; 0-10% of stream banks artificially armored or lined	Bar formation, mostly from coarse gravel; and/or 10-40% of stream banks artificially armored or obviously channelized	Recent but moderate deposition of gravel and coarse sand on bars; and/or embankments on both banks; and/or 40-80% of banks artificially armored; or channel lined in concrete	Heavy deposits of fine material, extensive bar development; OR recent channelization or dredging evident; or over 80% of banks artificially armored
7. Bank Stability[g]	Upper bank stable, 0-10% of banks with erosional scars and little potential for future problems	Moderately stable. 10-30% of banks with erosional scars, mostly healed over. Slight potential in extreme floods	Moderately unstable. 30-60% of banks with erosional scars and high erosion potential during extreme high flow	Unstable. Many eroded areas. "Raw" areas frequent along straight sections and bends. Side slopes >60° common
8. Embeddedness[h]	Percentage that gravel, cobble, and boulder particles are surrounded by line sediment or flocculent material.			
9. Channel Flow Status[i]	Percentage that water fills available channel			
10. Shading[j]	Percentage of segment that is shaded (duration is considered in scoring). 0% = fully exposed to sunlight all day in summer; 100% = fully and densely shaded all day in summer			
11. Riparian Buffer[k]	Minimum width of vegetated buffer in meters; 50 meters maximum; see back of Habitat Assessment Data Sheet for buffer type and land cover immediately adjacent to buffer			

Habitat Parameter	Optimal (16-20)	Sub-Optimal (11-15)	Marginal (6-10)	Poor (0-5)
12. Aesthetic Rating[l]	Little or no evidence of human refuse present; vegetation visible from stream essentially in a natural state	Human refuse present in minor amounts; and/or channelization present but not readily apparent; and/or minor disturbance of riparian vegetation	Refuse present in moderate amounts; and/or channel-ization readily apparent; and/or moderate disturbance of riparian vegetation	Human refuse abundant and un-sightly: and/or extensive unnatural channelization; and/or nearly complete lack of vegetation
13. Remoteness[m]	Stream segment more than 1/4 mile from nearest road; access difficult and little or no evidence of human activity	Stream segment within 1/4 of but not immediately accessible to roadside access by trail; site with moderately wild character	Stream within 1/4 mile of roadside and accessible by trail; anthropogenic activities readily evident	Segment immediately adjacent to roadside access; visual , olfactory, and/or auditory displeasure experienced

a) **Instream Habitat** Rated based on perceived value of habitat to the fish community. Within each category, higher scores should be assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores should be assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where ferric hydroxide is present, instream habitat scores are not lowered unless the precipitate has changed the gross physical nature of the substrate. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

b) **Epifaunal Substrate** Rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, floculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.

c) **Velocity/Depth Diversity** Rated based on the variety of velocity/depth regimes present at a site (slow-shallow, slow-deep, fast-shallow, and fast-deep). As with embeddedness, this metric may result in lower scores in low-gradient streams but will provide a statewide information on the physical habitat found in Maryland streams.

d) **Pool/Glide/Eddy Quality** Rated based on the variety and spatial complexity of slow- or still-water habitat within the sample segment. It should be noted that even in high-gradient segments, functionally important slow-water habitat may exist in the form of larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris or other types of cover for fish.

e) **Riffle/Run Quality** Rated based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

f) **Channel Alteration** Is a measure of large-scale changes in the shape of the stream channel. Channel alteration includes: concrete channels, artificial embankments, obvious straightening of the natural channel, rip-rap, or other structures, as well as recent bar development. Ratings for this metric are based on the presence of artificial structures as well as the existence, extent, and coarseness of point bars, side bars, and mid-channel bars which indicate the degree of flow fluctuations and substrate stability. Evidence of channelization may sometimes be seen in the form of berms which parallel the stream channel.

g) **Bank Stability** Rated based on the presence/absence of riparian vegetation and other stabilizing bank materials such as boulders and rootwads, and frequency/size of erosional areas. Sites with steep slopes are not penalized if banks are composed solely of stable materials.

h) **Embeddedness** Rated as a percentage based on the fraction of surface area of larger particles that is surrounded by fine sediments on the stream bottom. In low gradient streams with substantial natural deposition, the correlation between embeddedness and fishability or ecological health may be weak or non-existent, but this metric is rated in all streams to provide similar information from all sites statewide.

i) **Channel Flow Status** Rated based on the percentage of the stream channel that has water, with subtractions made for exposed substrates and islands.

j) **Shading** Rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by landforms.

k) **Riparian Buffer Zone** Based on the size and type of the vegetated riparian buffer zone at the site. Cultivated fields for agriculture which have bare soil to any extent are not considered as riparian buffers. At sites where the buffer width is variable or direct delivery of storm runoff or sediment to the stream is evident or highly likely, the smallest buffer in the segment. (e.g., 0 if parking lot runoff enters directly to the stream) is measured and recorded even though some of the segment may have a well developed buffer. In cases where the riparian zone on one side of the stream slopes away from the stream and there is no direct point of entry for runoff, the buffer on the other side of the stream should be measured and recorded and a comment made in comments section of the data sheet.

l) **Aesthetic Rating** Rated based on the visual appeal of the site and presence/absence of human refuse, with highest scores assigned to stream segments with no human refuse and visually outstanding character.

m) **Remoteness** Rated based on the absence of detectable human activity and difficulty in accessing the segment.

Stream Name	Pool Quality	Riffle Quality	Channel Alteration	Bank Stability	Embeddedness	Channel Flow
BEAVERDAM CREEK	16	6	1	18	75	97
BEAVERDAM CREEK	16	5	11	10	65	100
BEAVERDAM CREEK	18	2	11	12	60	100
BEAVERDAM CREEK	3	6	18	19	100	95
BEAVERDAM CREEK	10	6	6	18	40	80
BROAD RUN	12	6	9	5	45	60
BROAD RUN	12	6	7	10	25	85
BROAD RUN	6	5	12	15	20	50
BROAD RUN	8	7	16	18	20	85
BUCKLODGE BRANCH	16	8	12	7	40	55
CABIN JOHN CREEK	12	17	12	18	30	65
CABIN JOHN CREEK	16	9	2	20	35	100
CABIN JOHN CREEK	15	12	18	19	25	60
DRY SENECA CREEK	18	10	15	18	35	70
DRY SENECA CREEK	15	6	16	15	15	85
DRY SENECA CREEK	12	13	16	16	45	95
GREAT SENECA CREEK	8	14	16	17	25	75
GREAT SENECA CREEK	18	11	12	15	35	90
GREAT SENECA CREEK	11	6	18	14	65	95
GUNNERS BRANCH	8	6	16	16	30	75
HENSON CREEK	17	12	15	16	45	70
HENSON CREEK	17	16	16	16	35	90
HENSON CREEK	19	11	11	16	40	75
HENSON CREEK	16	12	15	15	25	65
LITTLE MONOCACY R.	11	15	16	16	0	65
LITTLE PAINT BRANCH	7	6	13	18	35	97
LITTLE PAINT BRANCH	15	14	19	16	20	85
LITTLE SENECA CREEK	20	0	5	10	35	98
LITTLE SENECA CREEK	12	7	11	13	20	50
MAGRUDER BRANCH	13	9	16	8	20	85
MILL CREEK	16	12	8	7	40	92
MUDDY BRANCH	14	10	7	10	25	90
NORTH BRANCH ROCK CREEK	18	9	6	5	50	95
NORTH BRANCH ROCK CREEK	18	11	5	5	35	65
NORTHWEST BRANCH	10	15	4	19	45	85
NORTHWEST BRANCH	18	6	14	13	40	95
NORTHWEST BRANCH	16	10	5	4	35	85
NORTHWEST BRANCH	16	16	5	17	30	95
NORTHWEST BRANCH	18	1	6	17	30	90
NORTHWEST BRANCH	16	15	8	16	35	100
NW. BRANCH ANACOSTIA R.	19	6	5	13	35	80
PISCATAWAY CREEK	16	12	8	16	35	60
PISCATAWAY CREEK	20	11	14	12	45	50
PISCATAWAY CREEK	8	14	16	16	25	80
ROCK CREEK	16	16	16	10	40	95
ROCK CREEK	11	15	15	11	25	100
ROCK CREEK	10	16	17	14	35	85
SENECA CREEK	16	14	1	18	35	85
SLIGO CREEK	9	9	18	18	20	80

Stream Name	Latitude	Longitude	Woody Debris	Rootwads	Instream Habitat	Epifaunal Substrate	Velocity/Depth Diversity
TEN MILE CREEK	39.2270000	77.3110000	0	0	2	5	5
UT TO BEAVERDAM CREEK	38.9230000	76.8860000	6	2	17	11	14
UT TO CABIN JOHN CREEK	39.0549972	77.1350000	0	0	8	8	2
UT TO CABIN JOHN CREEK	39.0260000	77.1930000	0	0	12	12	7
UT TO LITTLE MONOCACY R.	39.2210000	77.3660000	0	2	15	16	10
UT TO LITTLE SENECA CREEK	39.2080000	77.2760000	0	0	14	16	10
UT TO MILL CREEK	39.1340000	77.1610000	2	1	12	14	10
UT TO NORTHWEST BRANCH	39.0960000	77.0130000	0	0	16	9	12
UT TO NORTHWEST BRANCH	39.1160000	77.0349972	6	0	7	1	5
UT TO PISCATAWAY CREEK	38.7599972	76.9320000	5	1	11	4	11
UT TO PISCATAWAY CREEK	38.7330000	76.8660000	0	1	10	5	11
UT TO POTOMAC R.	39.1550000	77.5170000	0	0	5	6	7
UT TO POTOMAC R.	39.0830000	77.3949972	1	1	13	5	11
UT TO POTOMAC R.	39.1980000	77.4599972	1	1	15	11	12
UT TO ROCK CREEK	39.0710000	77.0799972	5	2	13	15	9
UT TO ROCK CREEK	39.1610000	77.1320000	0	0	10	12	9
UT TO SENECA CREEK	39.1590000	77.2990000	1	2	13	10	11
UT TO SENECA CREEK	39.1630000	77.3170000	0	0	11	16	8
UT TO SENECA CREEK	39.1570000	77.3080000	0	0	16	15	13
UT TO WATTS BRANCH	39.0940000	77.1830000	0	1	15	17	12
WATTS BRANCH	39.0900000	77.1720000	5	1	16	17	15
WILD CAT BRANCH	39.2199972	77.2180000	5	1	16	17	15

Stream Name	Shading	Riparian Width	Aesthetic Rating	Maximum Depth	Stream Gradient	Straight Line Distance
TEN MILE CREEK	10	0	2	6	0.30	73
UT TO BEAVERDAM CREEK	97	50	12	84	1.20	57
UT TO CABIN JOHN CREEK	50	7	15	38	2.50	73
UT TO CABIN JOHN CREEK	95	0	15	18	1.50	52
UT TO LITTLE MONOCACY R.	75	20	13	44	2.00	67
UT TO LITTLE SENECA CREEK	95	12	4	42	2.00	57
UT TO MILL CREEK	55	50	12	47	1.50	70
UT TO NORTHWEST BRANCH	25	0	15	96	2.00	71
UT TO NORTHWEST BRANCH	5	50	17	38	0.10	64
UT TO PISCATAWAY CREEK	75	50	16	83	0.30	60
UT TO PISCATAWAY CREEK	55	0	12	74	1.00	68
UT TO POTOMAC R.	45	0	15	19	0.70	74
UT TO POTOMAC R.	95	50	15	51	2.50	43
UT TO POTOMAC R.	70	50	8	86	0.50	65
UT TO ROCK CREEK	95	22	20	33	1.50	61
UT TO ROCK CREEK	95	23	16	36	1.50	67
UT TO SENECA CREEK	70	0	16	70	2.10	64
UT TO SENECA CREEK	90	50	18	20	1.20	68
UT TO SENECA CREEK	85	0	12	82	0.50	71
UT TO WATTS BRANCH	75	0	10	73	1.00	64
WATTS BRANCH	95	50	17	92	1.50	50
WILD CAT BRANCH	95	50	17	92	1.5	50

ECOLOGY AND DISTRIBUTION OF FISH SPECIES COLLECTED IN THE POTOMAC WASHINGTON METRO BASIN

The species descriptions (Jenkins and Burkhead 1994, Rohde et al. 1994) and distributional maps which follow (Pages E7-E67) include those fish species collected during both random and non-random sampling in the Potomac Washington Metro basin as part of the 1994 and 1997 MBSS.

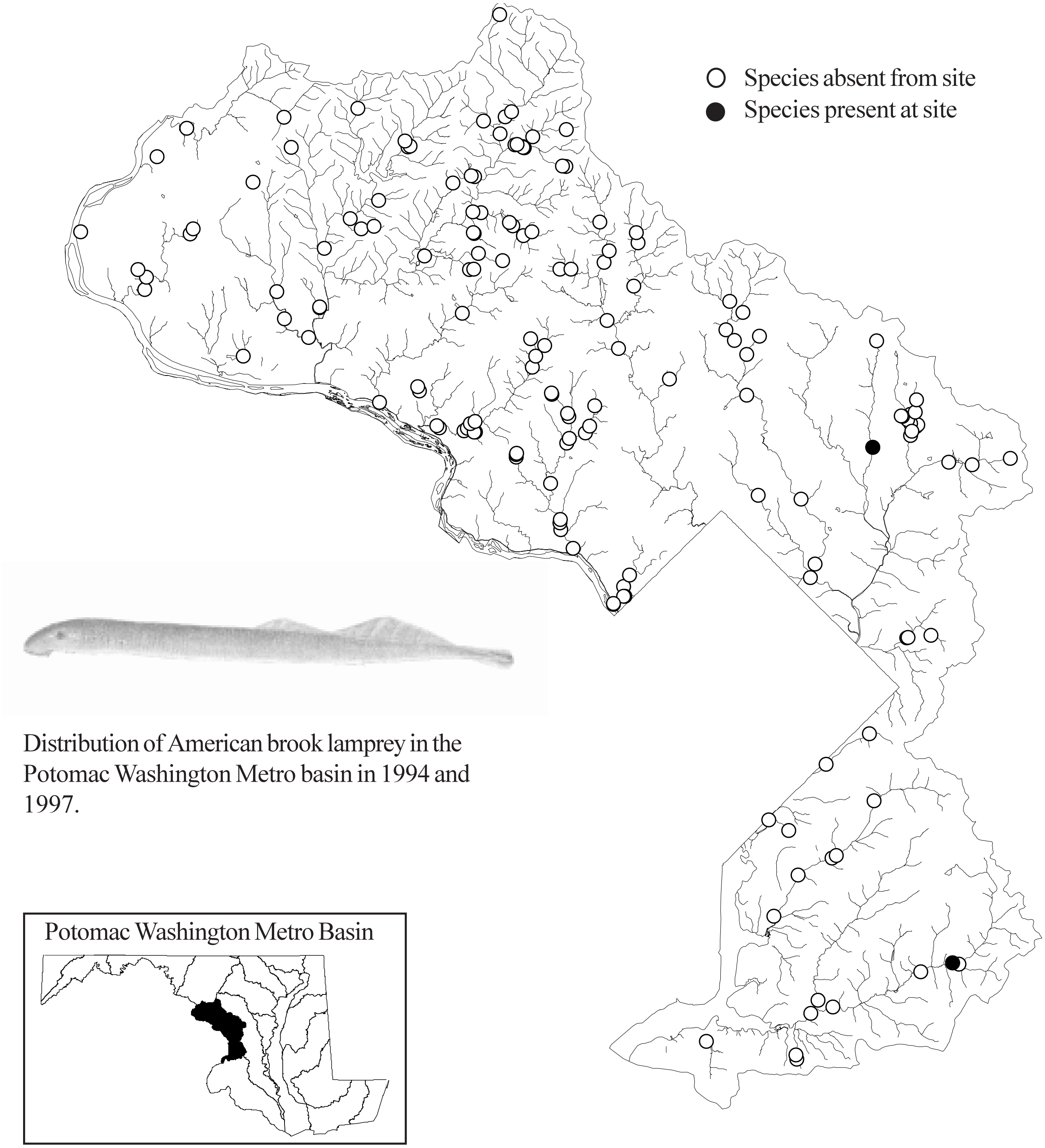
Common Name	*Family*	*Tolerance*	*Feeding Group*	*Page*	*Interesting Facts*
American brook lamprey	Lamprey	Intolerant	Filter Feeder	E-7	The larval stage of this species feeds largely on small algae, adults are not known to feed at all.
Least brook lamprey	Lamprey	Intolerant	Filter Feeder	E-8	The larval stage of this species may last a decade or more, the adult stage is short with death occurring after spawning.
Sea lamprey	Lamprey	Moderate	Filter Feeder	E-9	Adults live in the ocean and use freshwater streams to spawn and grow to maturity (anadromous).
American eel	Eel	Tolerant	Generalist	E-10	Although most of their life is spent in fresh water streams (up to 20 years or more), adults become silver in color and journey to the Sargasso sea to spawn (catadromous).
Gizzard shad	Herring	Moderate	Filter Feeder	E-11	Attempts have been made to stock this species as a forage base for game fish but they are only small enough to be taken by predators for a short time due to their rapid growth rate.
Chain pickerel	Pike	Moderate	Top Predator	E-12	This ambush predator feeds almost exclusively on other fish.
Redfin pickerel	Pike	Moderate	Top Predator	E-13	This member of the pike family is able to survive in small streams and ditches with extremely low dissolved oxygen.
Eastern mudminnow	Mudminnow	Tolerant	Invertivore	E-14	As the name implies, this species buries itself into the mud during the day and is nocturnally active.
Blacknose dace	Minnow	Tolerant	Omnivore	E-15	This species is tolerant of a wide range of environmental conditions and pollutants. Statewide, its abundance is exceeded by only 1 other species.
Bluntnose minnow	Minnow	Tolerant	Omnivore	E-16	As the name implies, this species is characterized by an extremely blunt snout.
Central stoneroller	Minnow	Moderate	Algivore	E-17	Because of its long intestine (up to 8 times its body length), this species is incredibly efficient at digesting detritus and algae.

Common Name	*Family*	*Tolerance*	*Feeding Group*	*Page*	*Interesting Facts*
Comely shiner	Minnow	Moderate	Invertivore	E-18	This species is considered uncommon in Maryland.
Common shiner	Minnow	Moderate	Omnivore	E-19	This species often becomes more abundant when cold water streams become stressed by high temperatures.
Common carp	Minnow	Tolerant	Omnivore	E-20	This minnow is tolerant of many environmental conditions and can survive in highly degraded habitat.
Creek chub	Minnow	Tolerant	Generalist	E-21	Like other minnow species, this minnow doesn't have teeth around the jaw. However, it is quite capable of taking large prey items and readily strikes at lures intended for trout.
Cutlips minnow	Minnow	Moderate	Invertivore	E-22	This species is named for the presence of a bony lower jaw bordered on each side by a soft oval lobe.
Eastern silvery minnow	Minnow	Moderate	Algivore	E-23	An inhabitant of flat water areas, including tidal freshwater, this species is tolerant of low dissolved oxygen and siltation.
Fallfish	Minnow	Moderate	Generalist	E-24	The male fallfish may build a large nest of gravel over 3 feet high to protect its mates eggs.
Fathead minnow	Minnow	Tolerant	Omnivore	E-25	As a result of bait-bucket introductions, this minnow is widely distributed throughout the eastern United States.
Golden shiner	Minnow	Tolerant	Omnivore	E-26	This species is a favorite food of largemouth bass. It has been transported throughout the United States as a result of bait bucket introductions.
Goldfish	Minnow	Tolerant	Omnivore	E-27	This well known Asian fish was the first exotic fish species introduced to North America. Unfortunately, many new introductions still occur from tropical fish hobbyists.
Longnose dace	Minnow	Moderate	Omnivore	E-28	Its streamlined body shape and large fins allow this minnow to move around easily and remain stationary in fast currents.
River chub	Minnow	Moderate	Omnivore	E-29	During the breeding season, the male develops tubercles on its head and vigorously defends its nest from other males and egg-foraging predators.
Rosyface shiner	Minnow	Moderate	Invertivore	E-30	This species is an opportunistic feeder and preys on a variety of drifting and attached organisms.
Rosyside dace	Minnow	Intolerant	Invertivore	E-31	This minnow is considered to be sensitive to heavy siltation.
Satinfin shiner	Minnow	Moderate	Invertivore	E-32	This species is considered a good aquarium fish because of its active nature and ready acceptance of dried food.
Silverjaw minnow	Minnow	Moderate	Omnivore	E-33	This species is readily identified by a network of honeycomb-like canals below its eyes.

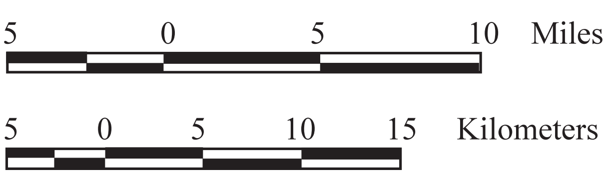
Common Name	*Family*	*Tolerance*	*Feeding Group*	*Page*	*Interesting Facts*
Spotfin shiner	Minnow	Moderate	Invertivore	E-34	This species occurs in generally clear streams of moderate gradient and in the shallows of reservoirs and lakes. It is a warmwater species known to form small schools that are occasionally mixed with other minnows.
Spottail shiner	Minnow	Moderate	Omnivore	E-35	This species is found in a wide range of habitats, including tidal freshwater areas where it can be highly abundant.
Swallowtail shiner	Minnow	Moderate	Invertivore	E-36	This species seems to use both minnow and sunfish nests for spawning, unlike other minnows which only spawn on other minnow nests.
Creek chubsucker	Sucker	Moderate	Invertivore	E-37	This species lacks a lateral line and therefore is easily distinguishable from other suckers in Maryland.
Golden Redhorse	Sucker	Moderate	Omnivore	E-38	The breeding behavior of males of this species is very aggressive. The males often engage in three fish shoving a matches, where one male butts another sideways toward third, who returns the hammering.
Northern hogsucker	Sucker	Intolerant	Invertivore	E-39	Considered to be an aggressive feeder, this species has been known to overturn stones and gravel in search of food. Because of its highly camouflaged coloration, large schools of this species often go unnoticed by the casual observer.
Shorthead redhorse	Sucker	Moderate	Omnivore	E-40	Although thought to be the most widespread redhorse, this species is easily killed by pollution and excessive siltation. It received its name due to its rather small head that is markedly downsloped to the snout tip.
White sucker	Sucker	Tolerant	Omnivore	E-41	Large white suckers have been reported to reach 17 years of age and lengths of over 23 inches. This is the most widely distributed sucker species in Maryland.
Brown bullhead	Catfish	Tolerant	Omnivore	E-42	Although considered native to Maryland, this species has been widely introduced throughout the United States to provide fishing opportunities.
Channel catfish	Catfish	Moderate	Omnivore	E-43	This is probably the most familiar and popular catfish in North America. In addition to its popularity with anglers, it a prized food fish that is widely raised in hatcheries. It is common in the Potomac River mainstem.
Margined madtom	Catfish	Moderate	Invertivore	E-44	This is a highly nocturnal species which requires hiding places to thrive. The spines of margined madtoms are venomous and can inflict considerable pain if handled incorrectly.

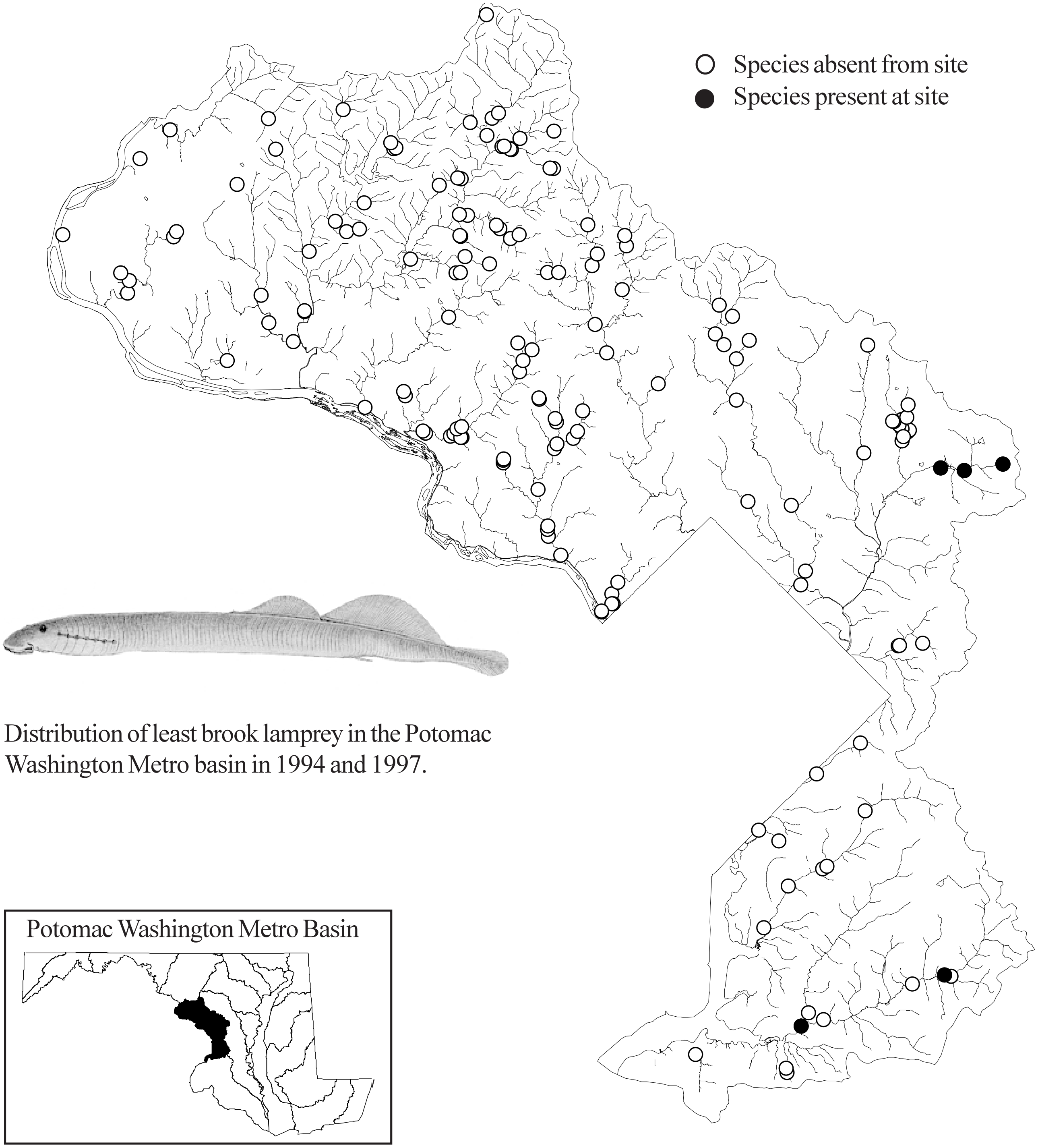
Common Name	*Family*	*Tolerance*	*Feeding Group*	*Page*	*Interesting Facts*
White catfish	Catfish	Moderate	Omnivore	E-45	A Chesapeake Bay native, this species has been widely isplaced by channel catfish, an introduced species.
Yellow bullhead	Catfish	Tolerant	Omnivore	E-46	Although bullheads are considered bottom feeders, when given the opportunity they are quite capable of catching and eating fish such as minnows and sunfish.
Brown trout	Trout	Moderate	Top Predator	E-47	This European species was widely introduced prior to 1900 and has contributed to the widespread decline of brook trout in the eastern United States. Because of its wariness, this trout presents a great challenge to both spin and fly fishermen.
Rainbow trout	Trout	Moderate	Top Predator	E-48	Although ranked among the top five sought after gamefish in North America, hatchery-reared fish are not considered desirable by many fishing purists.
Banded killifish	Killifish	Moderate	Invertivore	E-49	As a result of its hardy nature and general abundance this species is often used as live bait.
Mummichog	Killifish	Moderate	Invertivore	E-50	This species is more commonly found in estuaries and can tolerate salinities up to 32 parts/ thousand.
Mosquitofish	Topminnow	Moderate	Invertivore	E-51	As the name implies, this species has been known to control mosquito populations by feeding on pupal and larval stages.
Mottled sculpin	Sculpin	Moderate	Insectivore	E-52	This species is primarily an insectivore and does the majority of its feeding nocturnally.
Potomac sculpin	Sculpin	Moderate	Insectivore	E-53	This sculpin is found only in the Potomac River basin.
White perch	Temperate bass	Moderate	Invertivore	E-54	This species spawns from late March through May, migrating from the lower portions of the Chesapeake Bay upstream to freshwater (semi-anadromous).
Black crappie	Sunfish	Moderate	Generalist	E-55	Found in swamps, ponds, lakes, reservoirs, and slack water of low to moderate-gradient streams and rivers, this species is usually found near aquatic vegetation, fallen trees, stumps, and other structure. Fallen trees are often placed around draw-down zones in reservoirs to attract this species.
Bluegill	Sunfish	Tolerant	Invertivore	E-56	This species has been widely introduced throughout the United States, and has flourished as a result of its tolerance to a variety of conditions.
Bluespotted sunfish	Sunfish	Moderate	Invertivore	E-57	This species is distinguished by long, spotted fins and iridescent silver to blue body spots contrasting with dark and other hues.

Common Name	Family	Tolerance	Feeding Group	Page	Interesting Facts
Green sunfish	Sunfish	Tolerant	Generalist	E-58	This species is intolerant of low pH streams, but tolerant of many other types of stress. The lowest pH stream site in the basin where this sunfish was collected at was 7.1.
Largemouth bass	Sunfish	Moderate	Top Predator	E-59	This species is considered the most popular gamefish in the United States and has been known to reach weights of over 20 pounds.
Longear sunfish	Sunfish	Moderate	Invertivore	E-60	This species was found at only three site, but it is more common in the mainstem of the Potomac River. This sunfish gets its name from its large earflap which is black with a pale margin.
Pumpkinseed	Sunfish	Moderate	Invertivore	E-61	This sunfish is tolerant of darkly-stained acidic waters and is a regular visitor to brackish waters.
Redbreast sunfish	Sunfish	Moderate	Generalist	E-62	Often found with smallmouth bass and other “cool water” species, this sunfish has been found in water warmer than 100^{o} F.
Rock bass	Sunfish	Moderate	Generalist	E-63	This big-mouthed sunfish is an ambush predator that feeds on a wide variety of minnows and aquatic insects.
Smallmouth bass	Sunfish	Moderate	Top Predator	E-64	One reason for this species’ popularity as a gamefish is its aggressive nature and frequent aerial acrobatics when hooked on light tackle.
Fantail darter	Perch	Moderate	Insectivore	E-65	Aided by its small, cone shaped mouth, this insect eater commonly forages in crevices and under rocks.
Greenside darter	Perch	Moderate	Insectivore	E-66	Of the genus *Etheostoma*, the greenside darter is the largest.
Tessellated darter	Perch	Moderate	Invertivore	E-67	The male tessellated darter has a curious behavior of frequently caring for nests containing eggs that it did not fertilize.

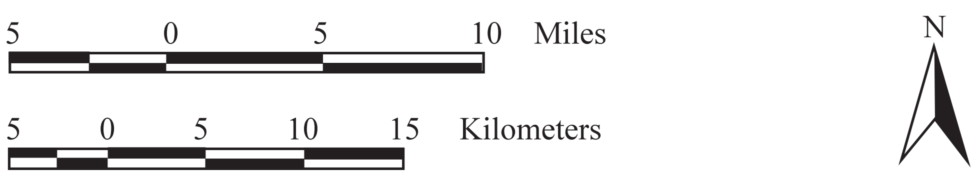


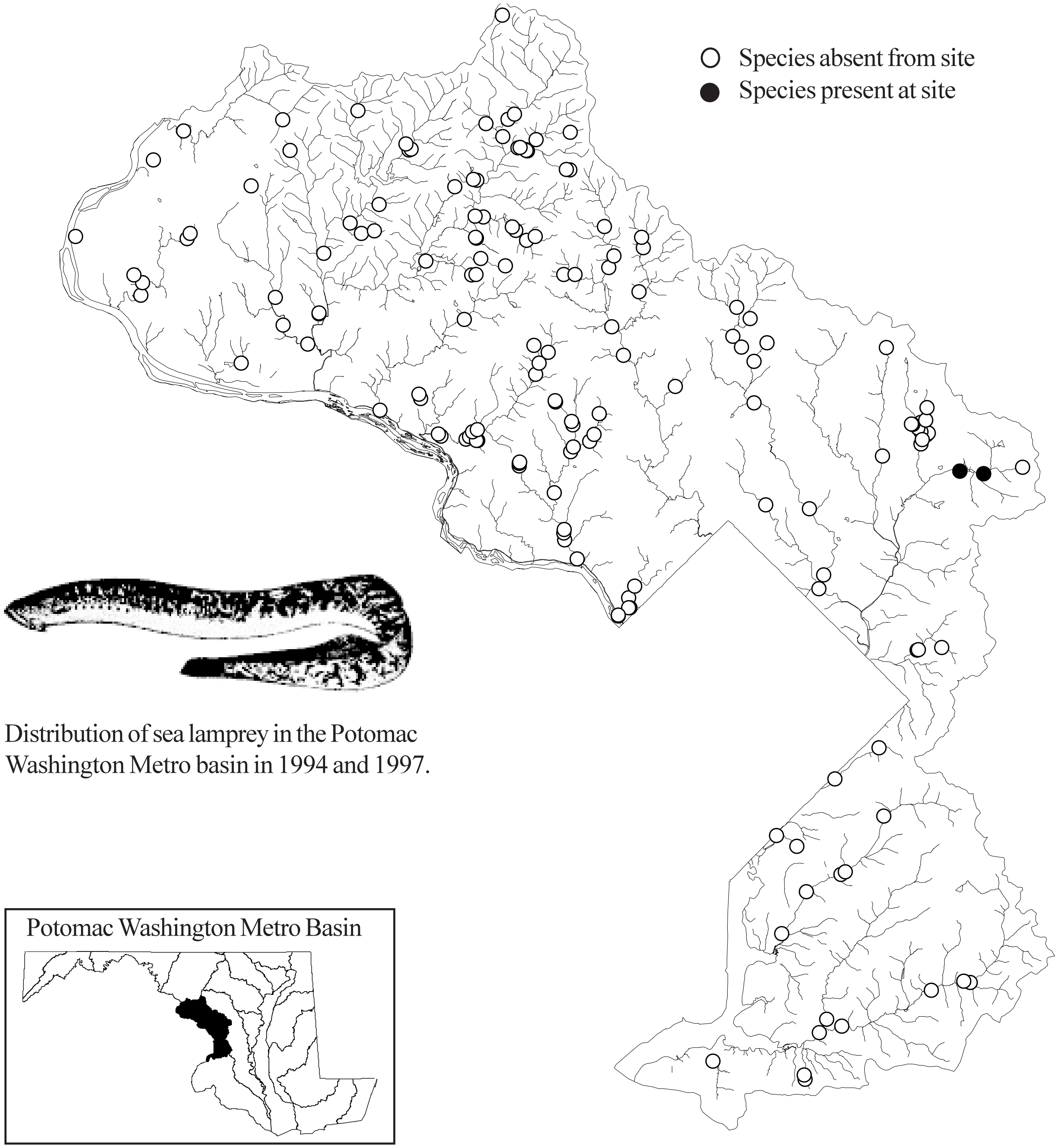
Distribution of American brook lamprey in the Potomac Washington Metro basin in 1994 and 1997.



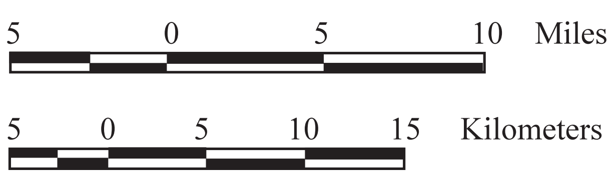


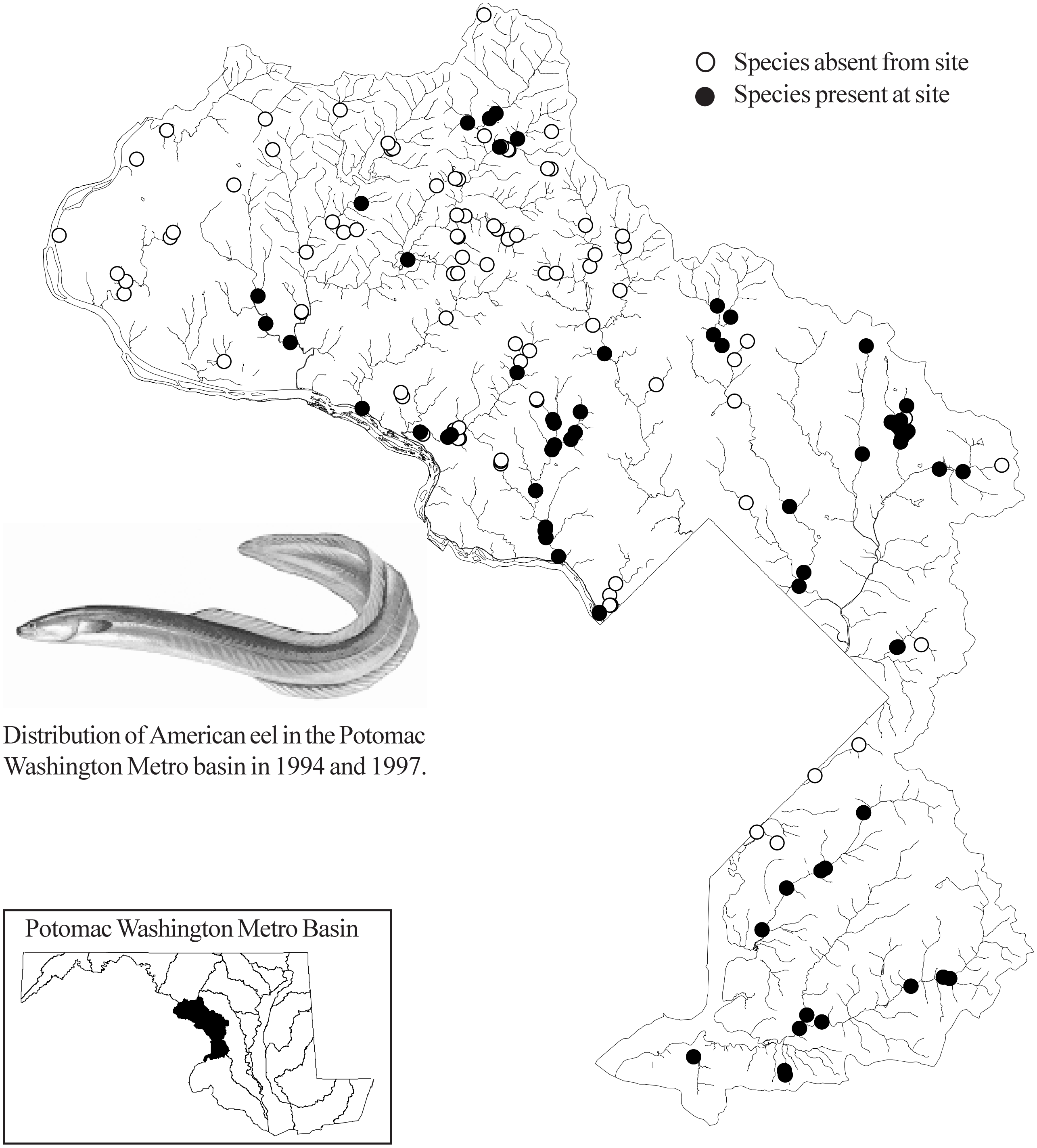
Distribution of least brook lamprey in the Potomac Washington Metro basin in 1994 and 1997.



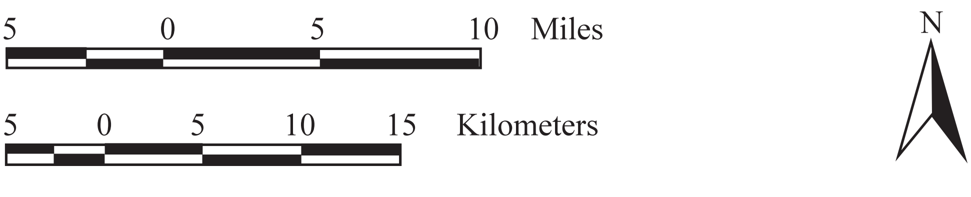


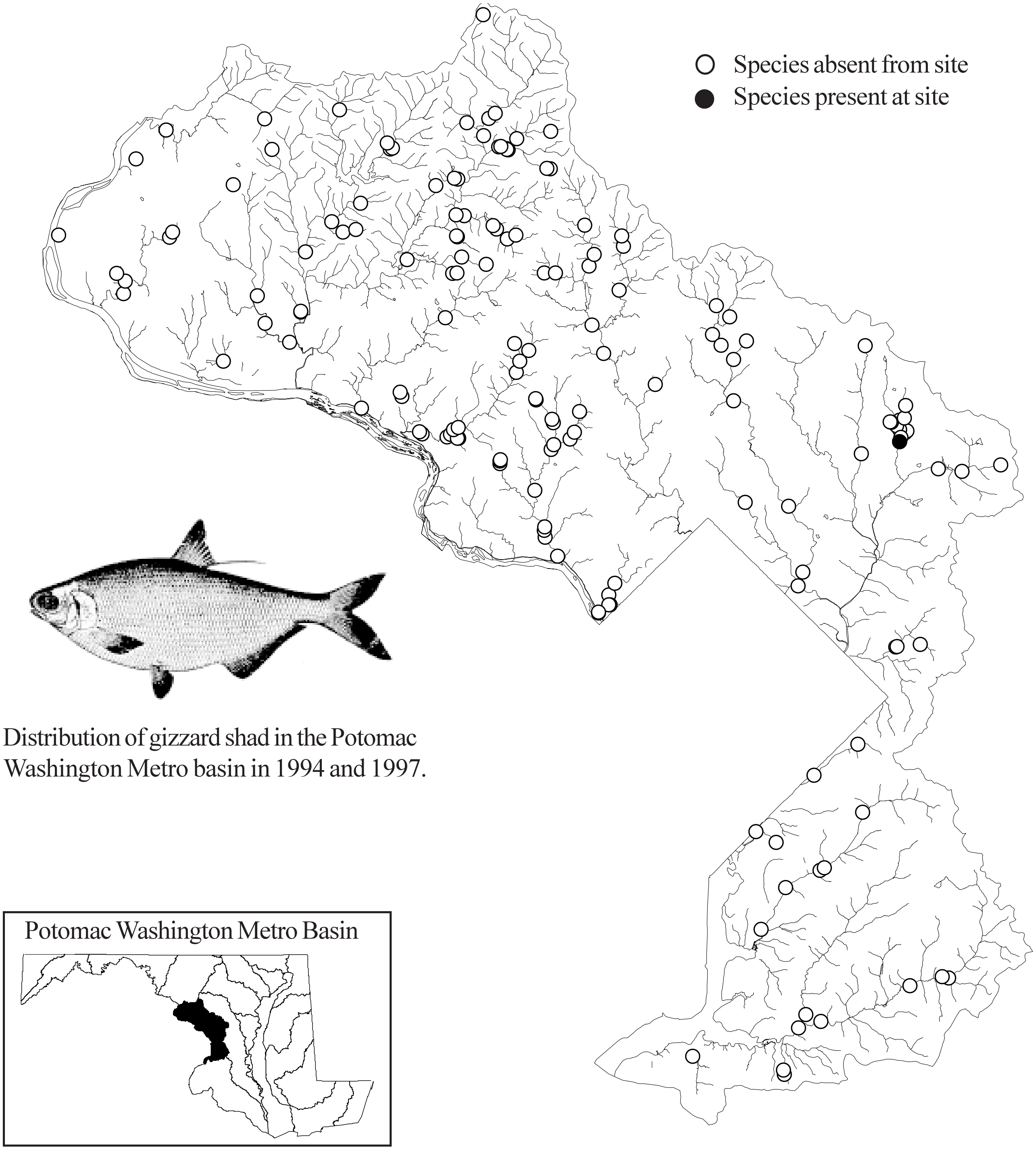
Distribution of sea lamprey in the Potomac Washington Metro basin in 1994 and 1997.



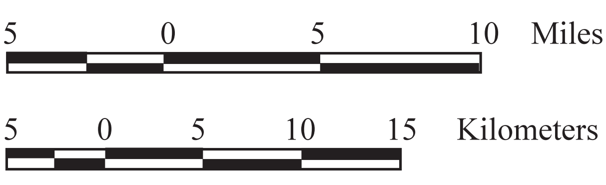


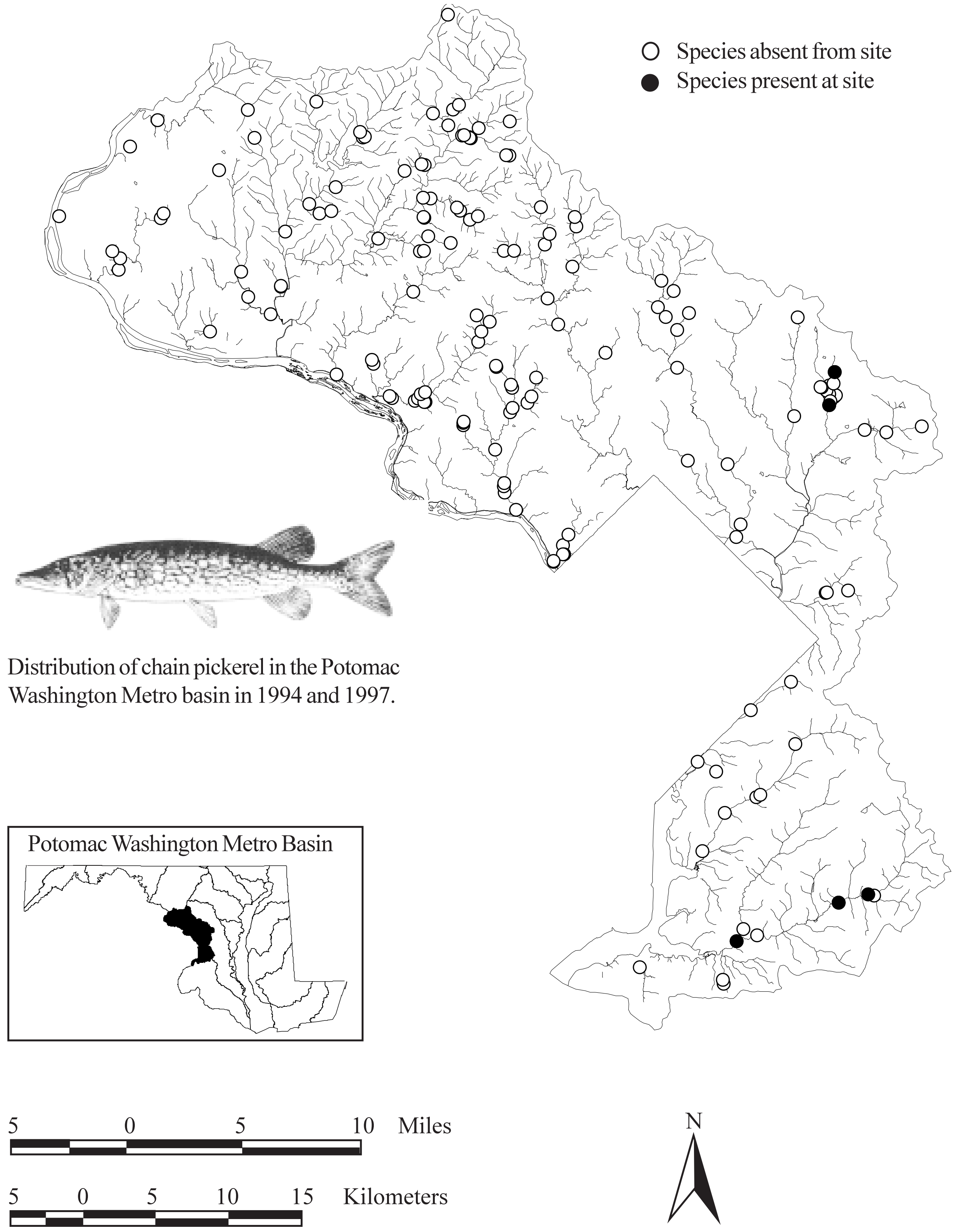
Distribution of American eel in the Potomac Washington Metro basin in 1994 and 1997.



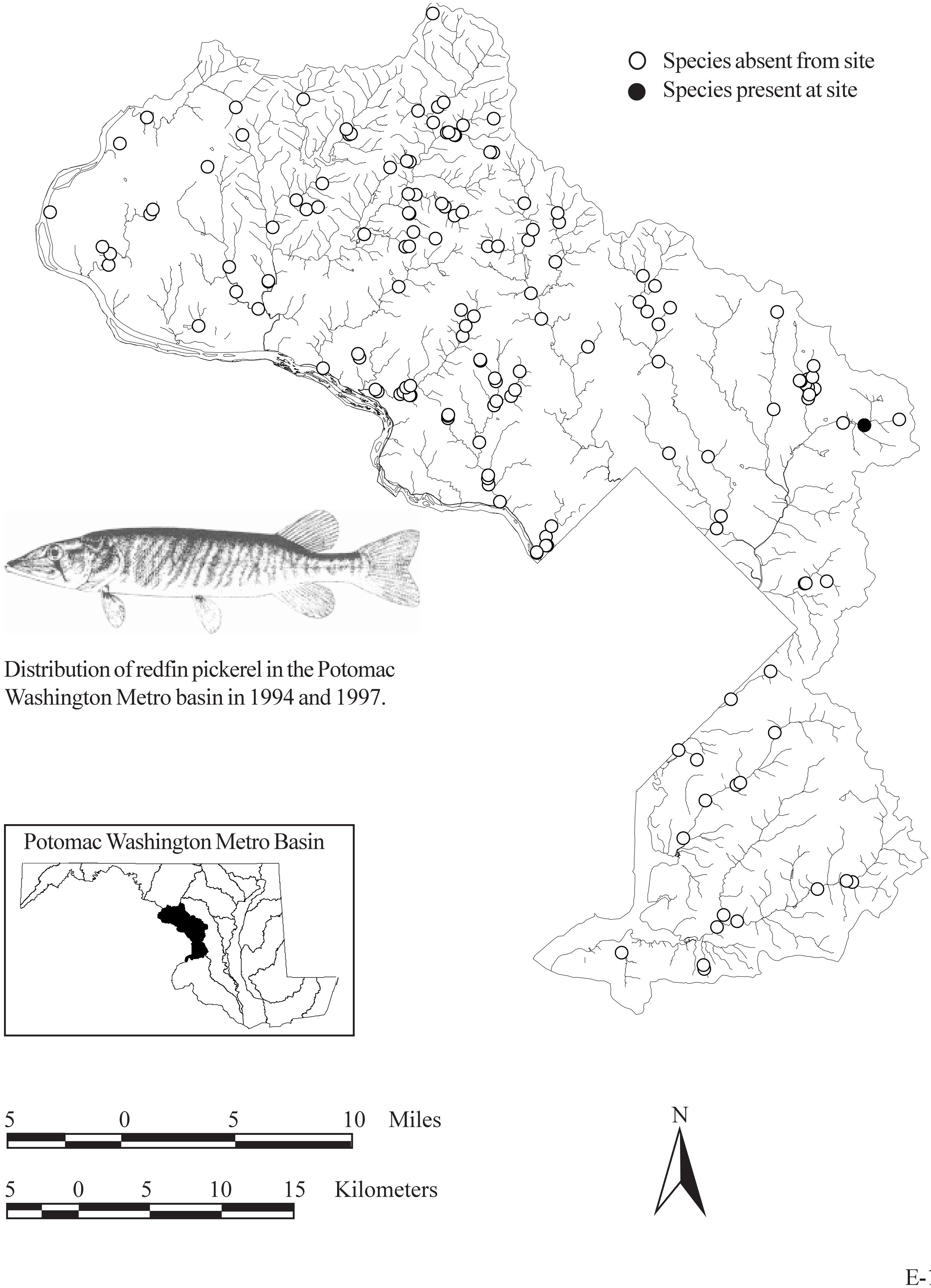


Distribution of gizzard shad in the Potomac Washington Metro basin in 1994 and 1997.

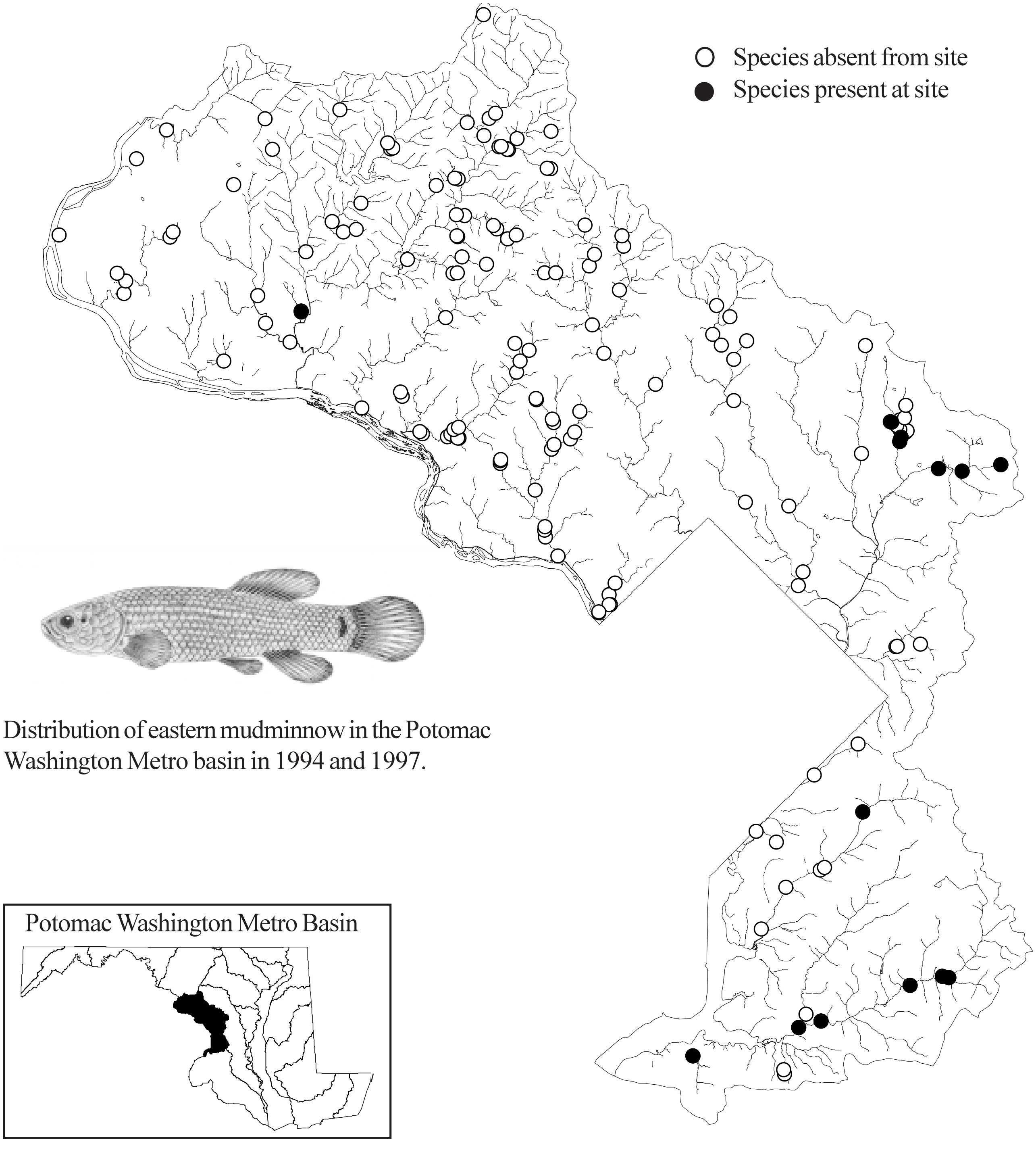




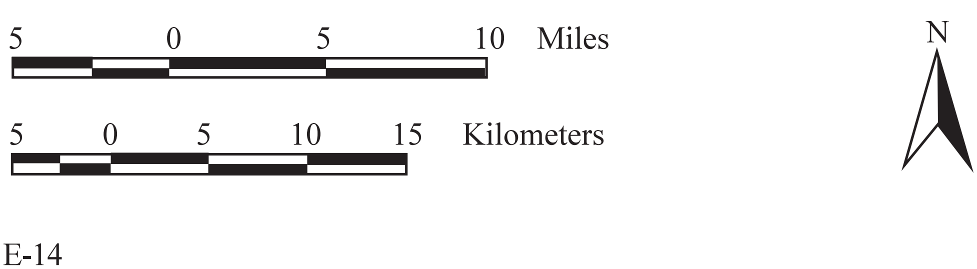
Distribution of chain pickerel in the Potomac Washington Metro basin in 1994 and 1997.

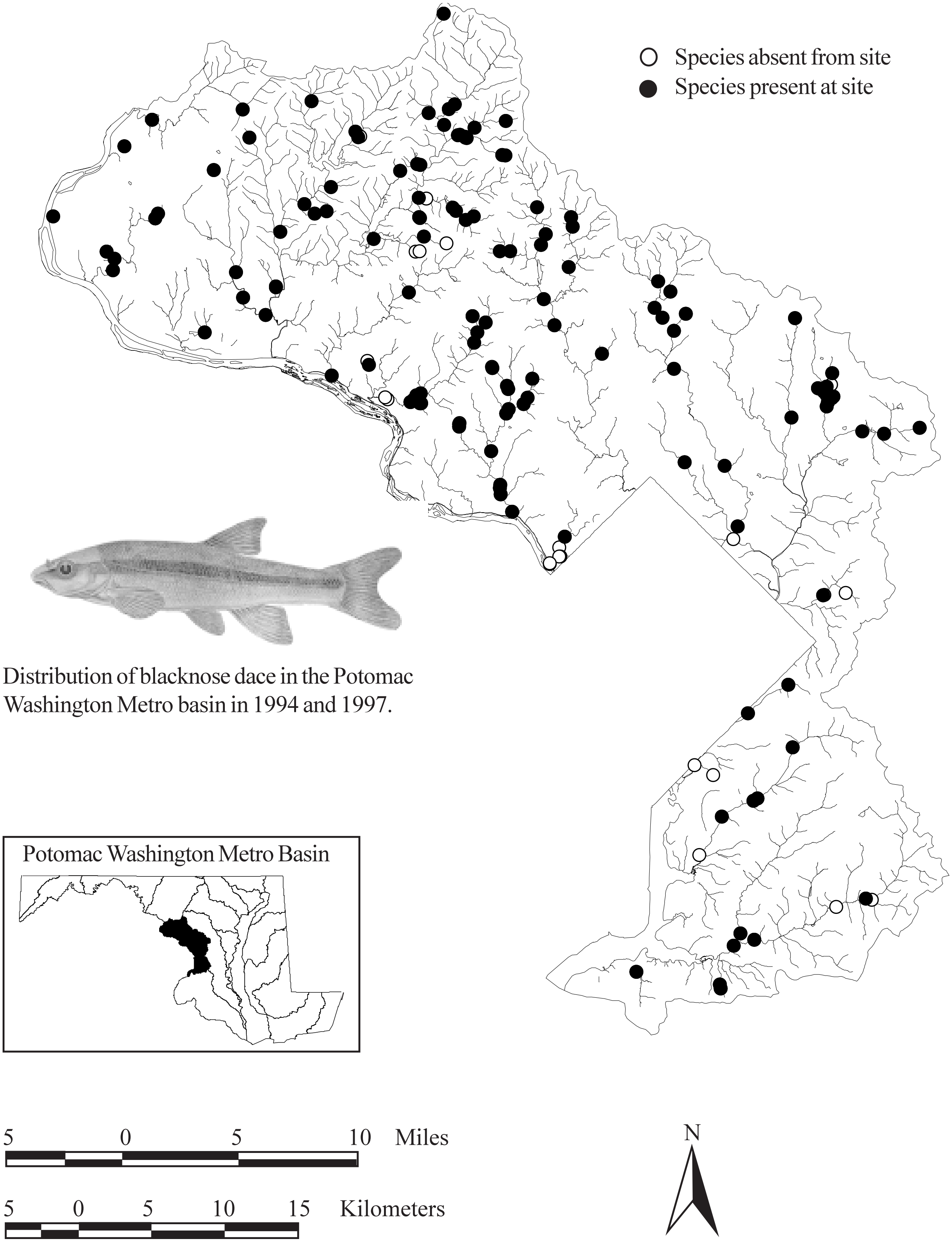


Distribution of redfin pickerel in the Potomac Washington Metro basin in 1994 and 1997.

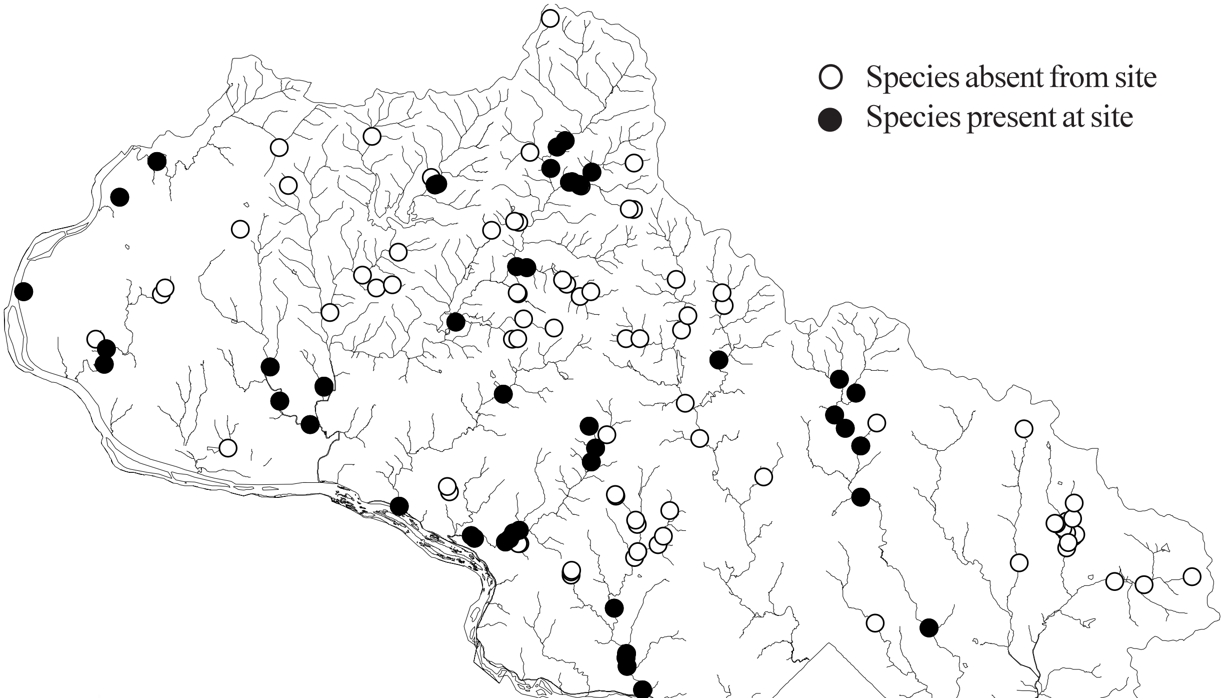


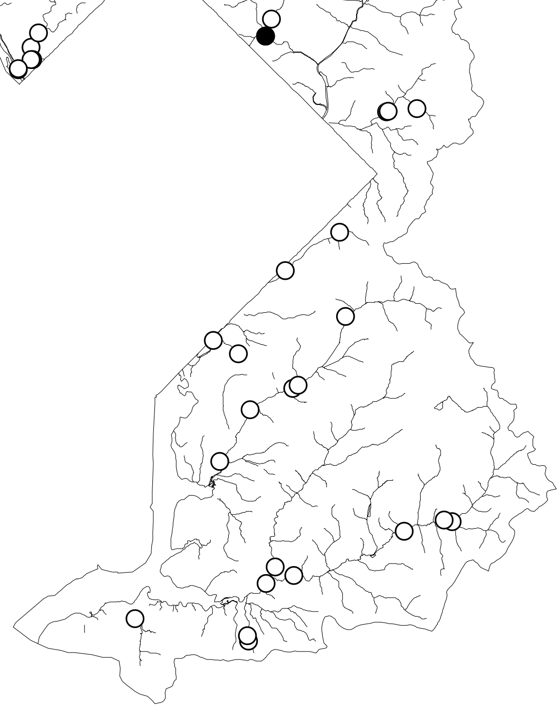
Distribution of eastern mudminnow in the Potomac Washington Metro basin in 1994 and 1997.

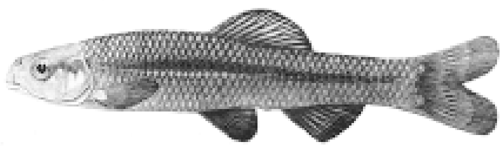




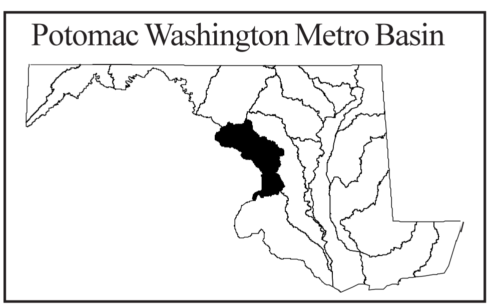
Distribution of blacknose dace in the Potomac Washington Metro basin in 1994 and 1997.

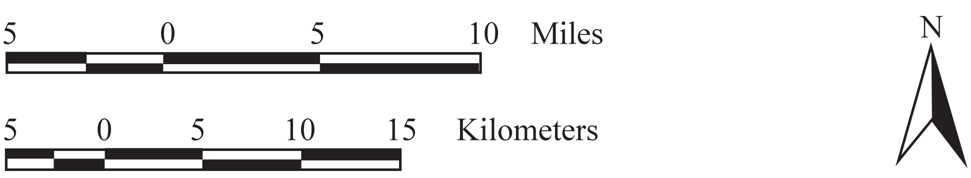


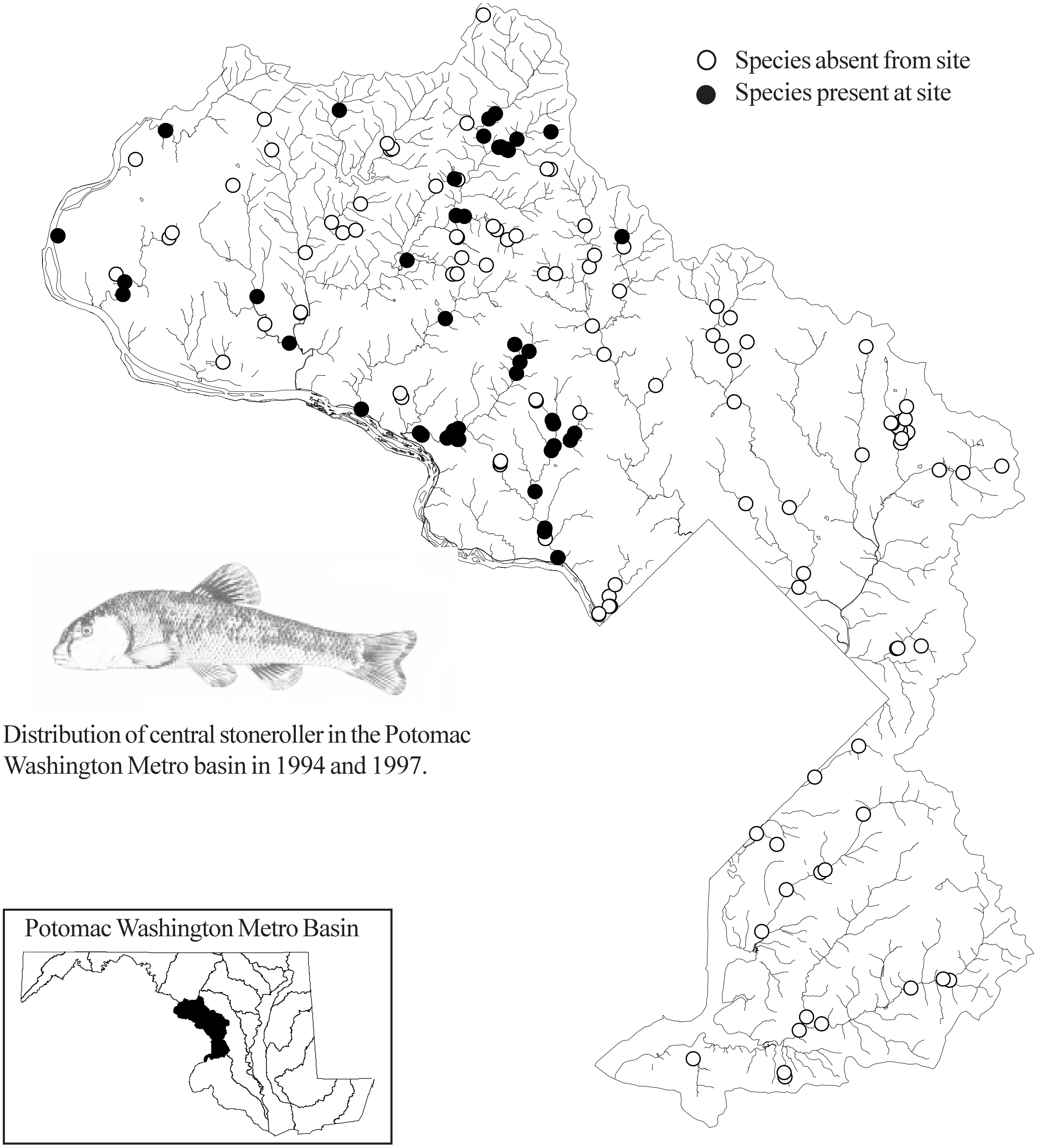




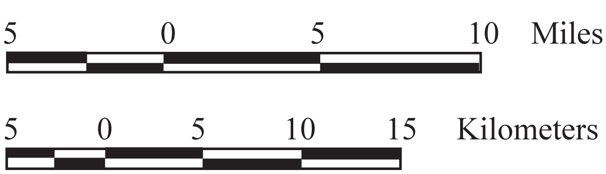
Distribution of bluntnose minnow in the Potomac Washington Metro basin in 1994 and 1997.

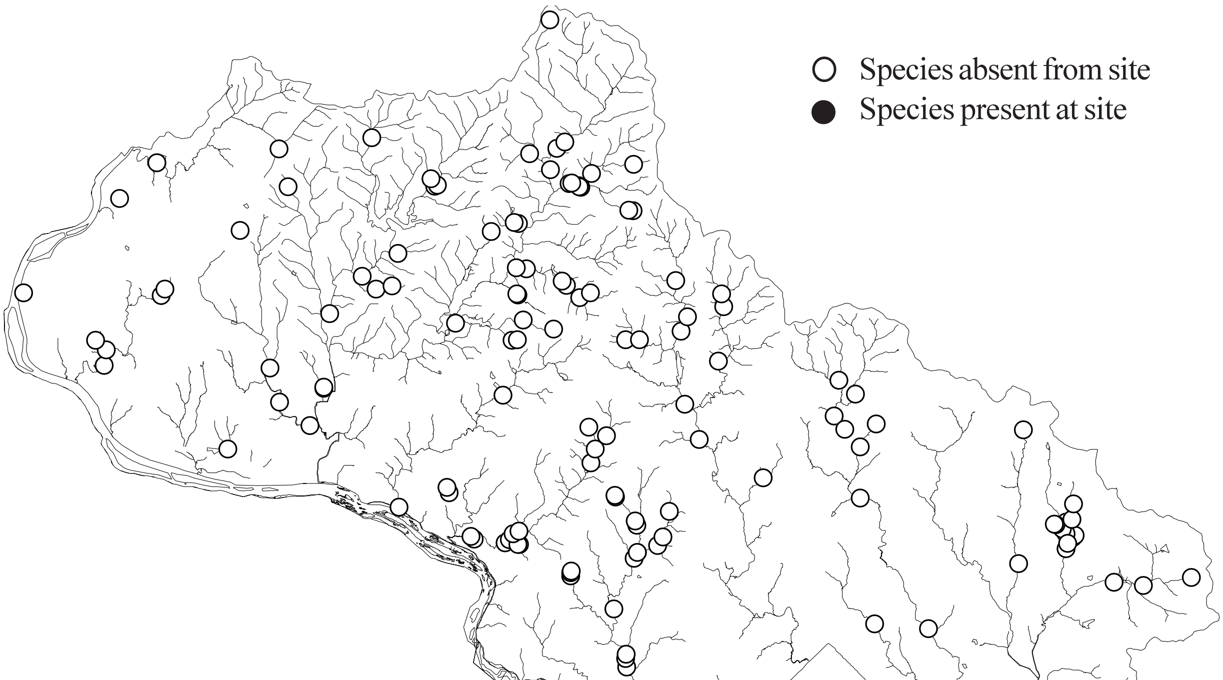


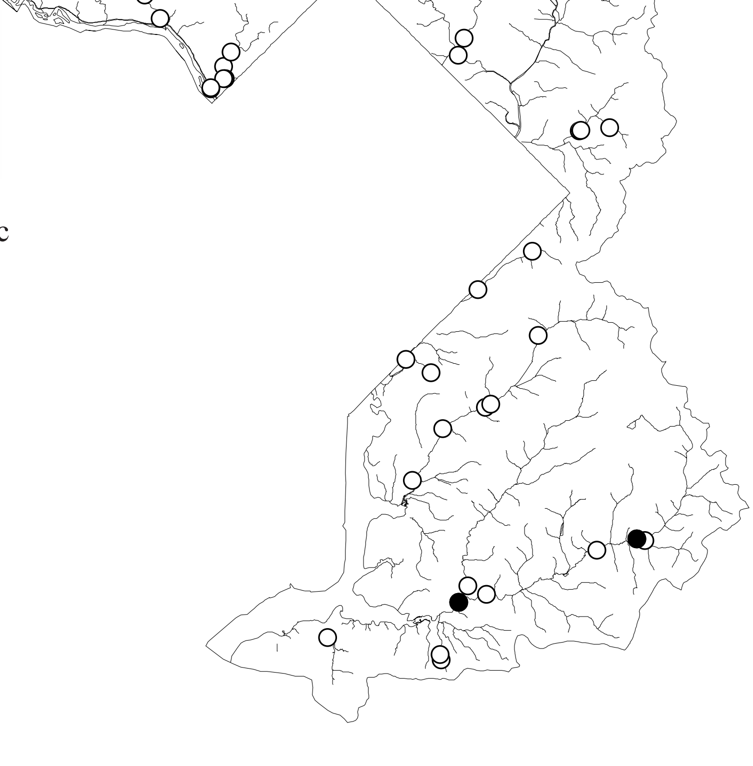


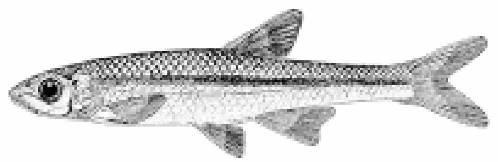


Distribution of central stoneroller in the Potomac Washington Metro basin in 1994 and 1997.

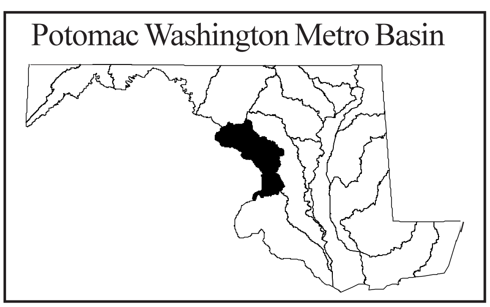


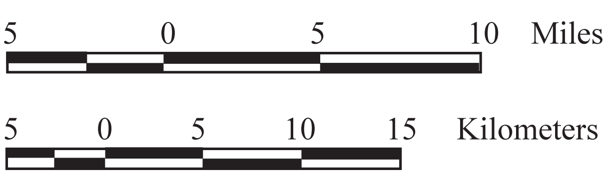


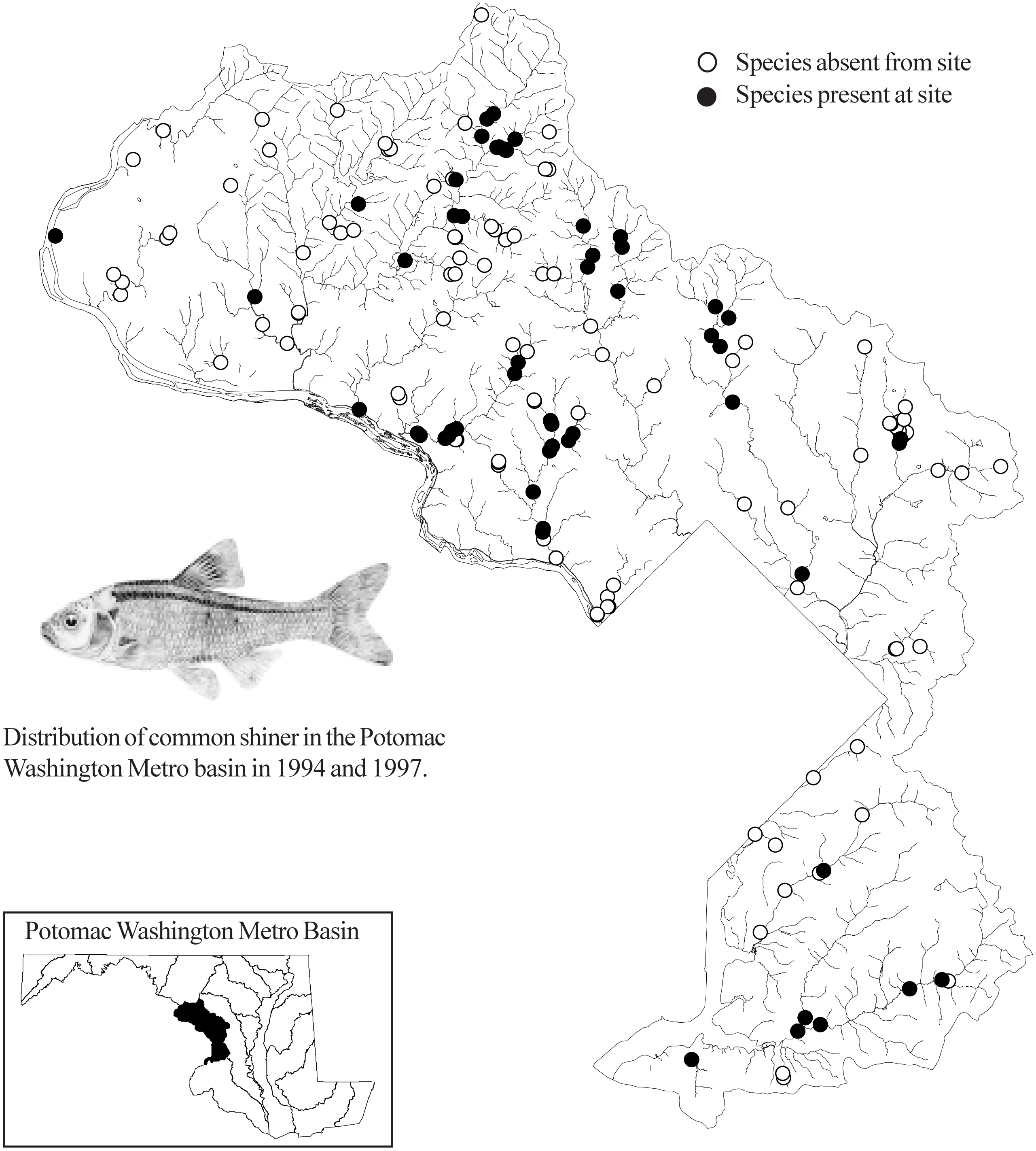




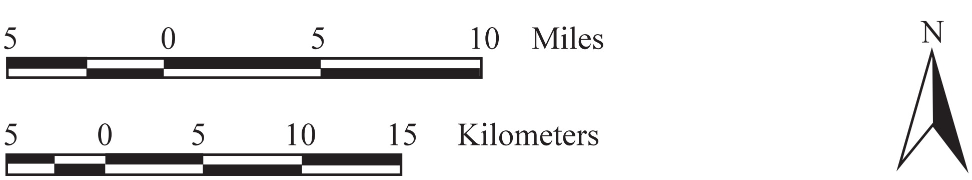
Distribution of comely shiner in the Potomac Washington Metro basin in 1994 and 1997.

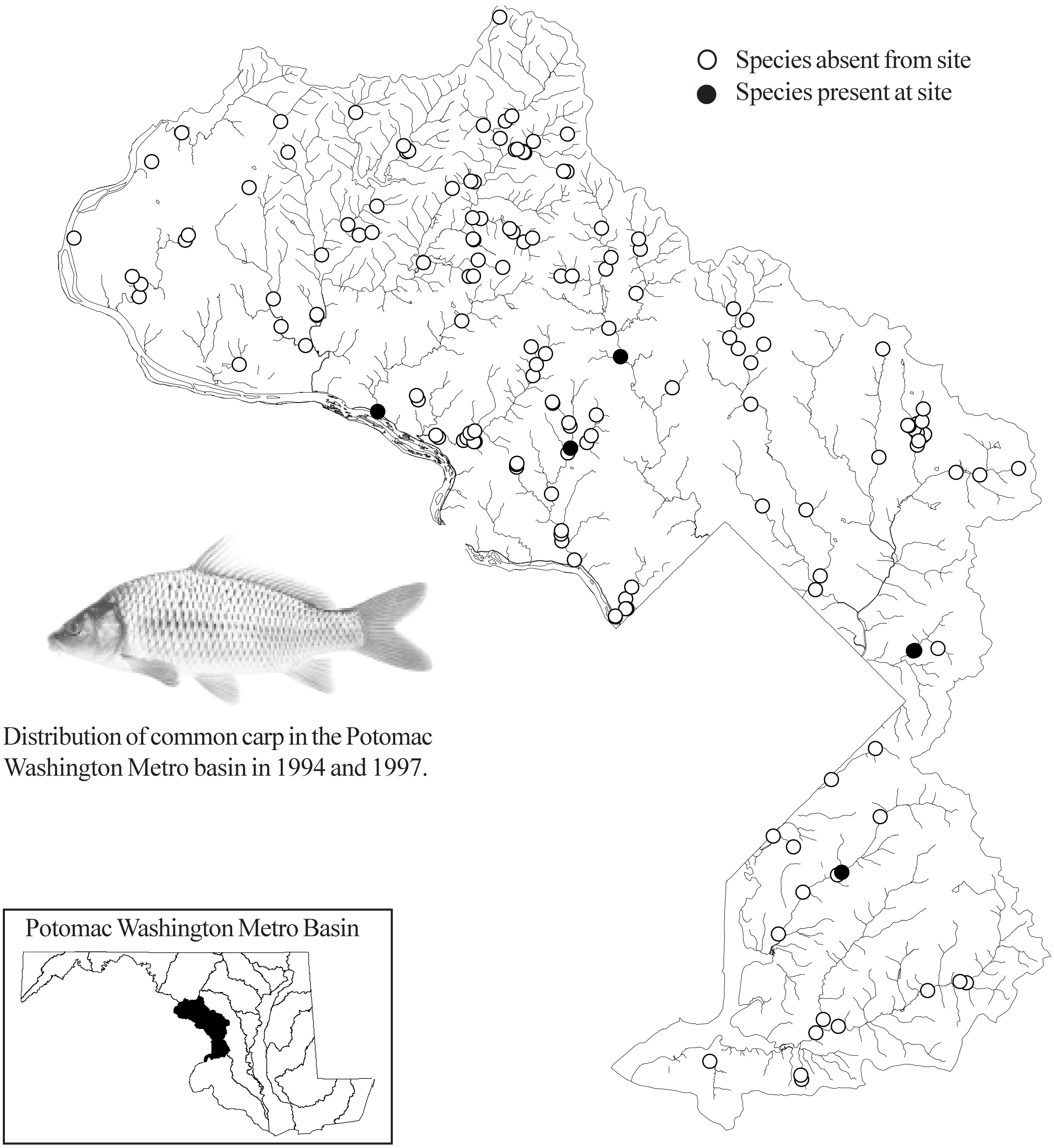




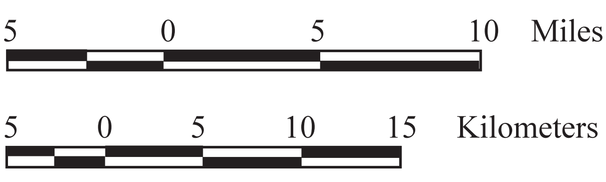


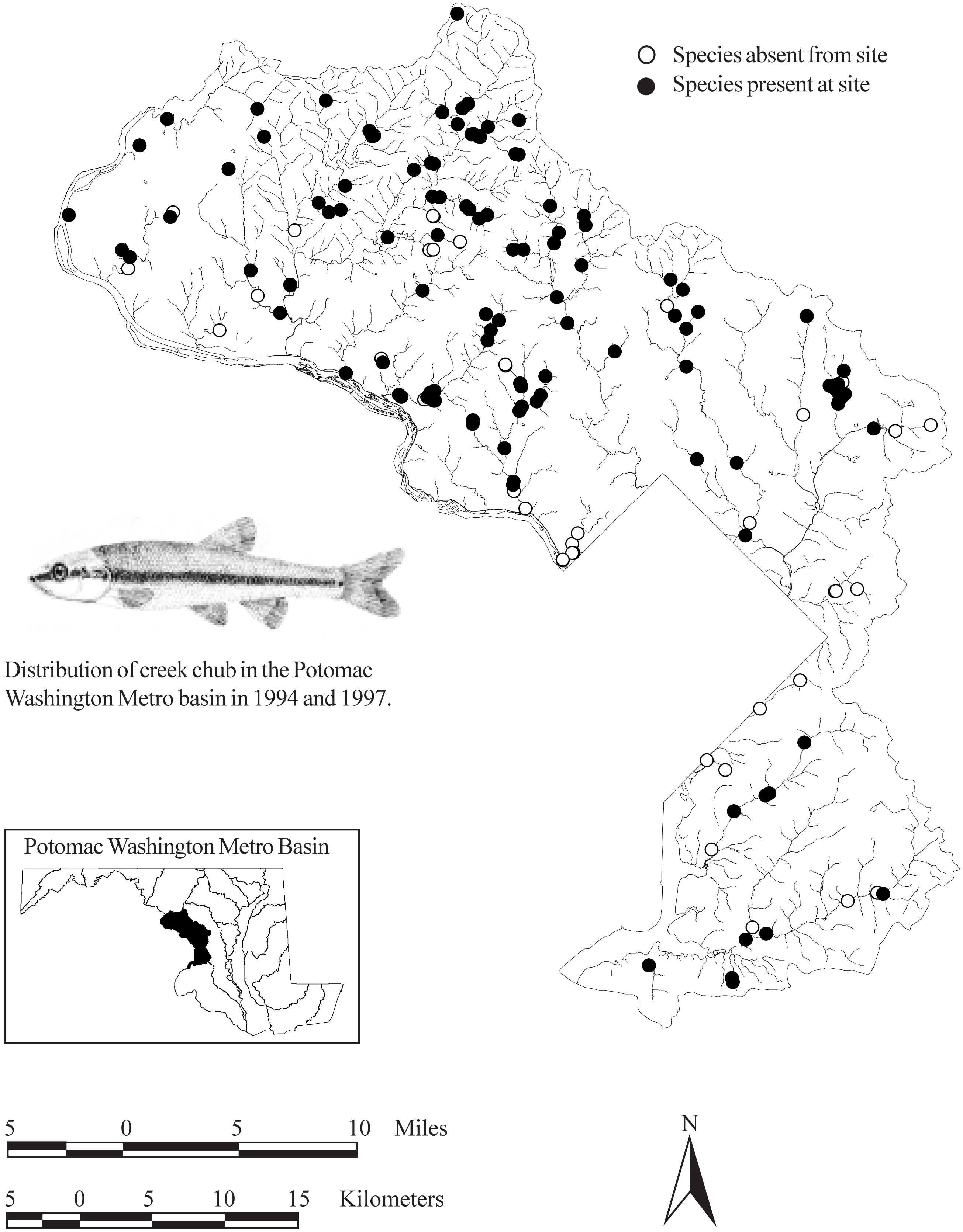
Distribution of common shiner in the Potomac Washington Metro basin in 1994 and 1997.



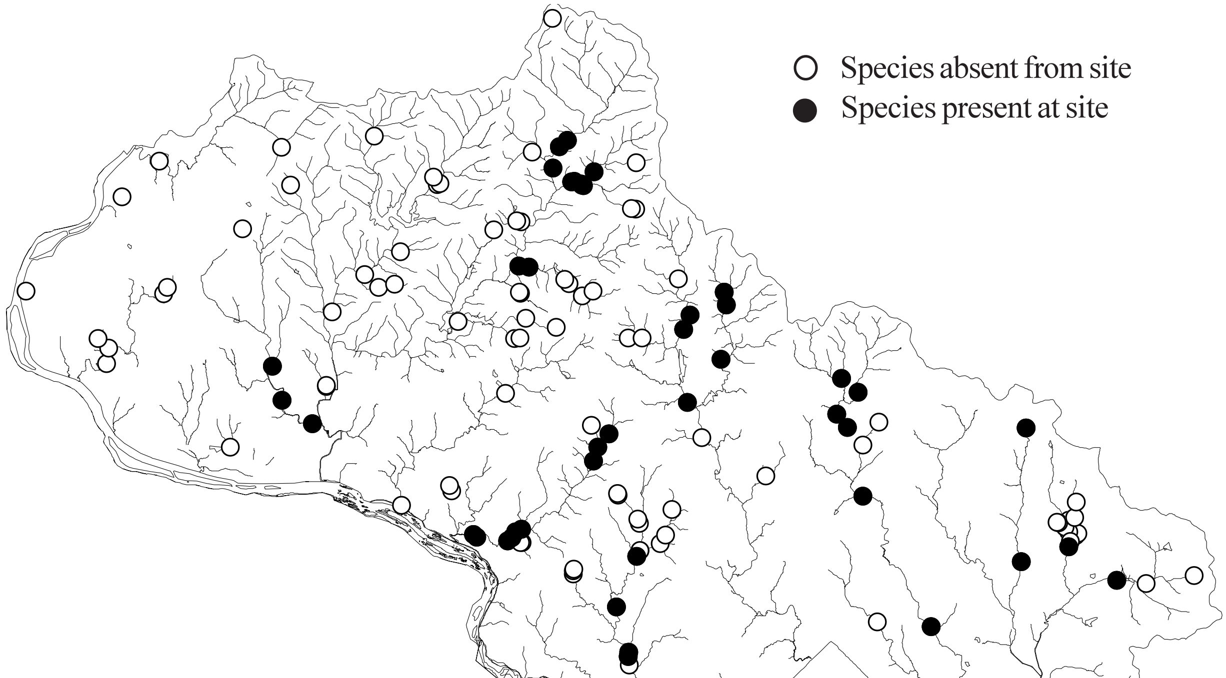


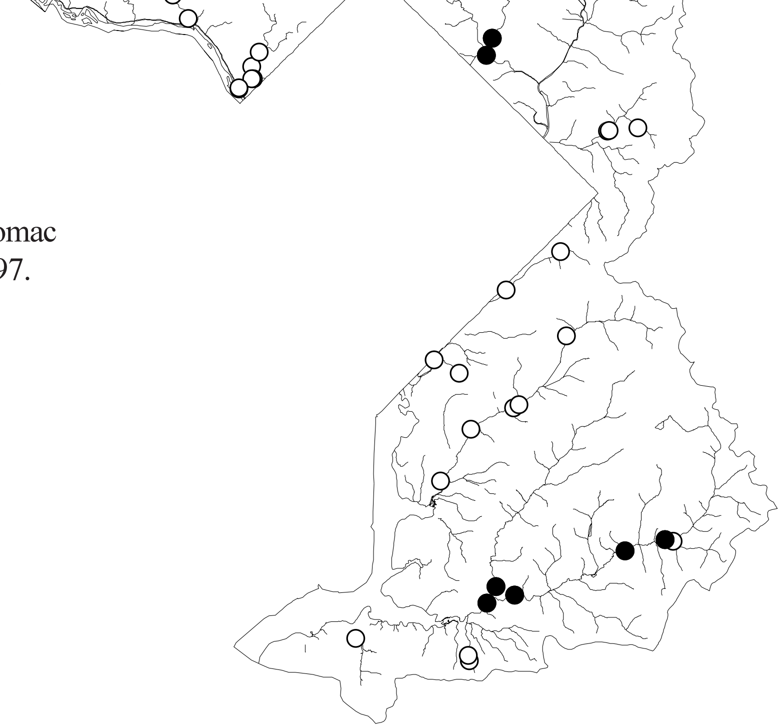
Distribution of common carp in the Potomac Washington Metro basin in 1994 and 1997.

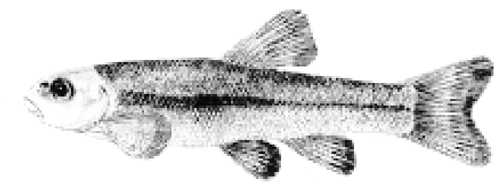




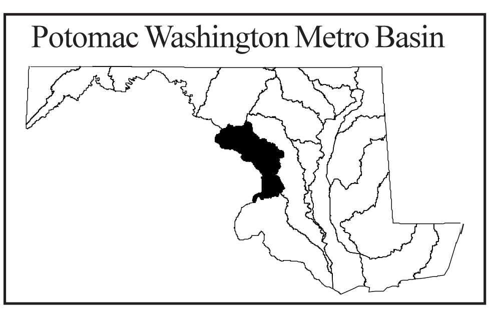
Distribution of creek chub in the Potomac Washington Metro basin in 1994 and 1997.

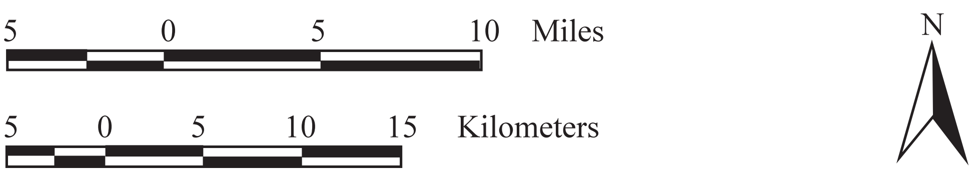


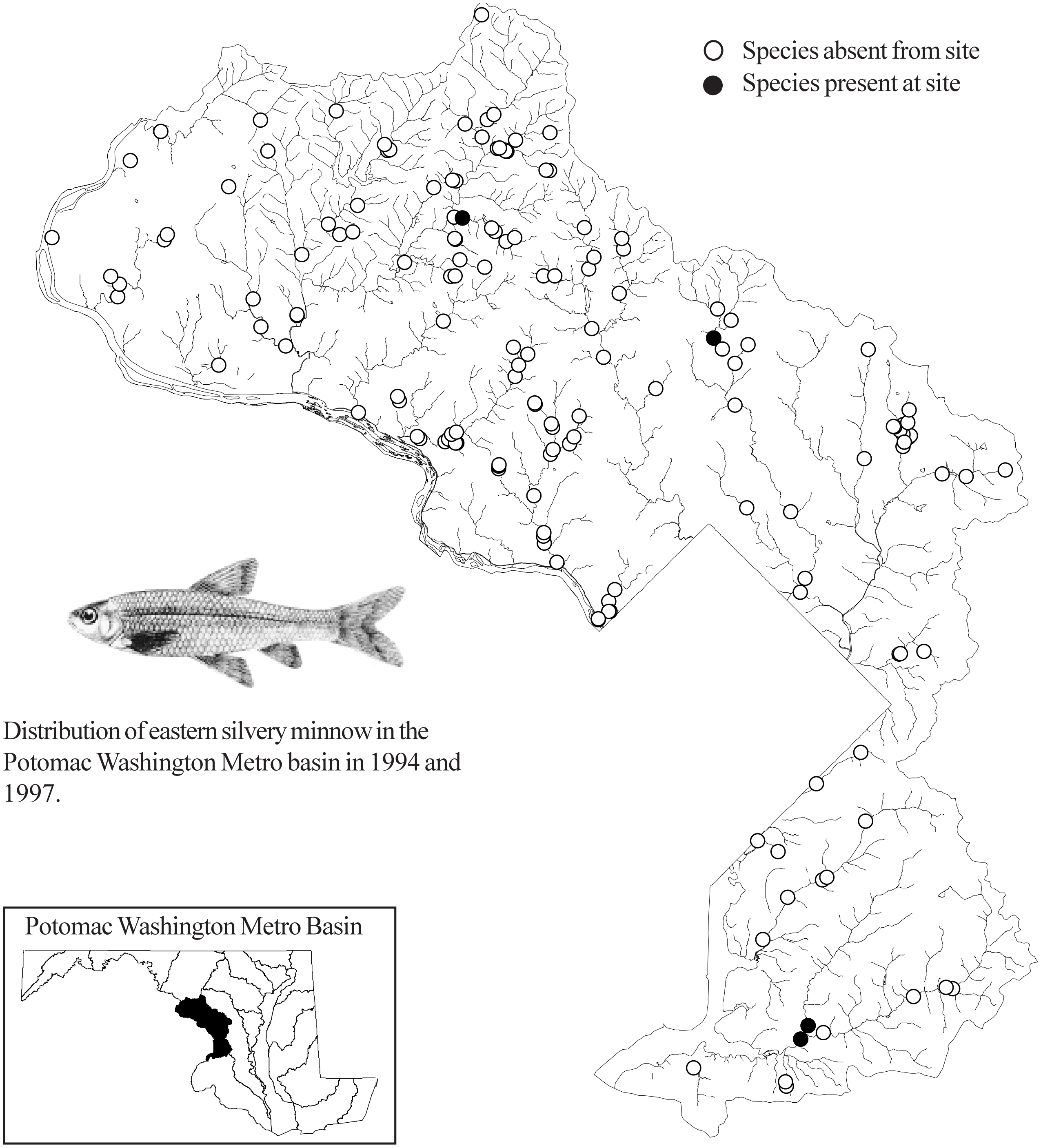




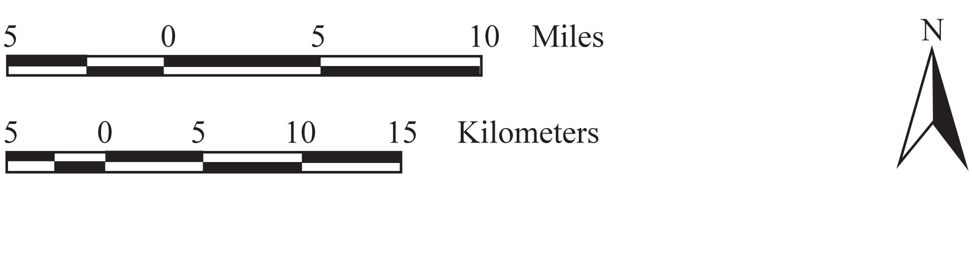
Distribution of cutlips minnow in the Potomac Washington Metro basin in 1994 and 1997.

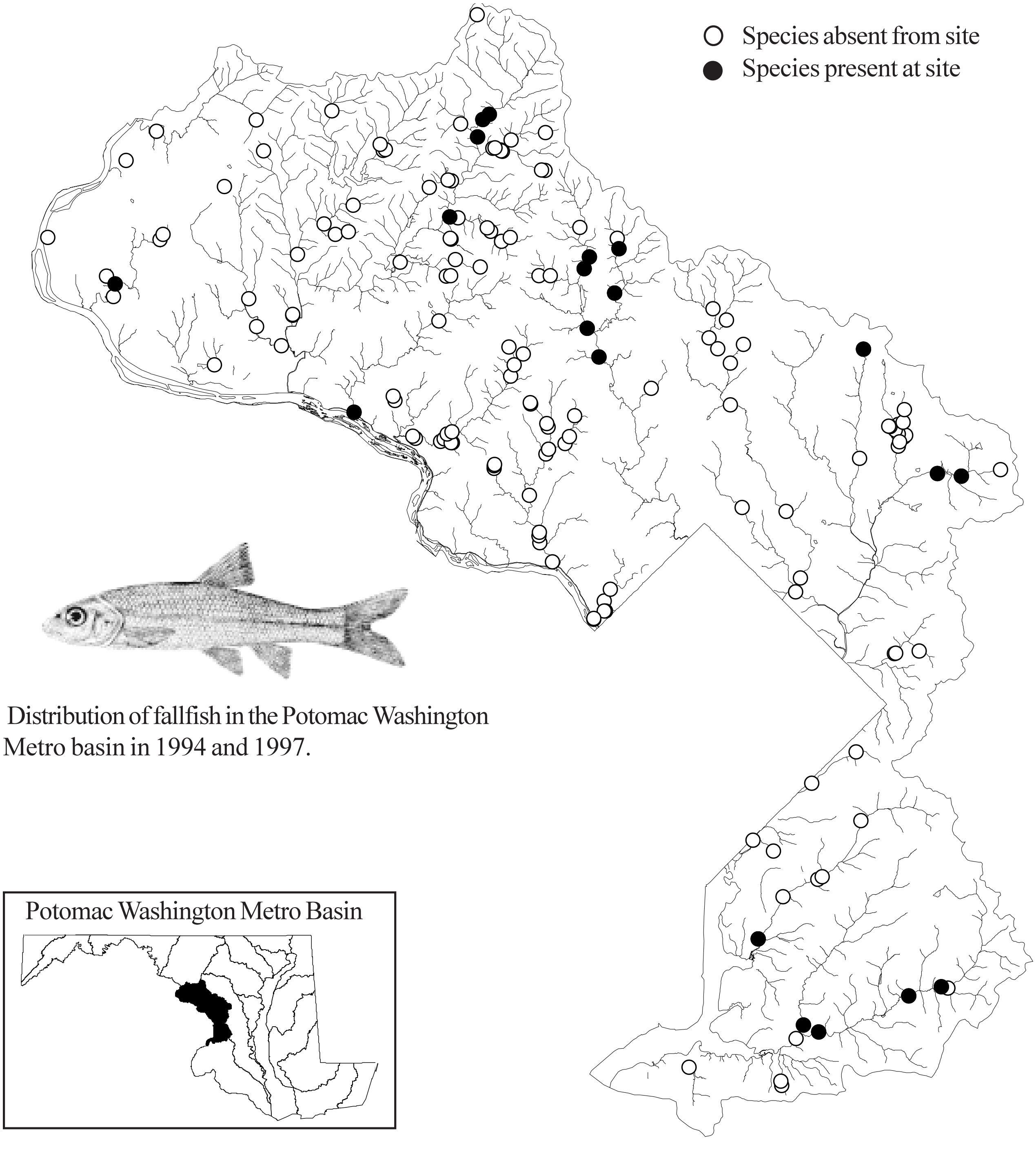




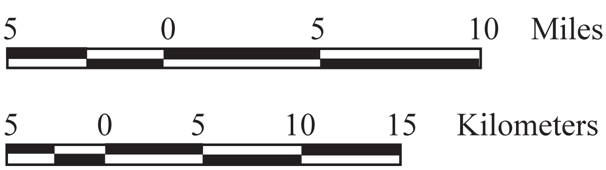


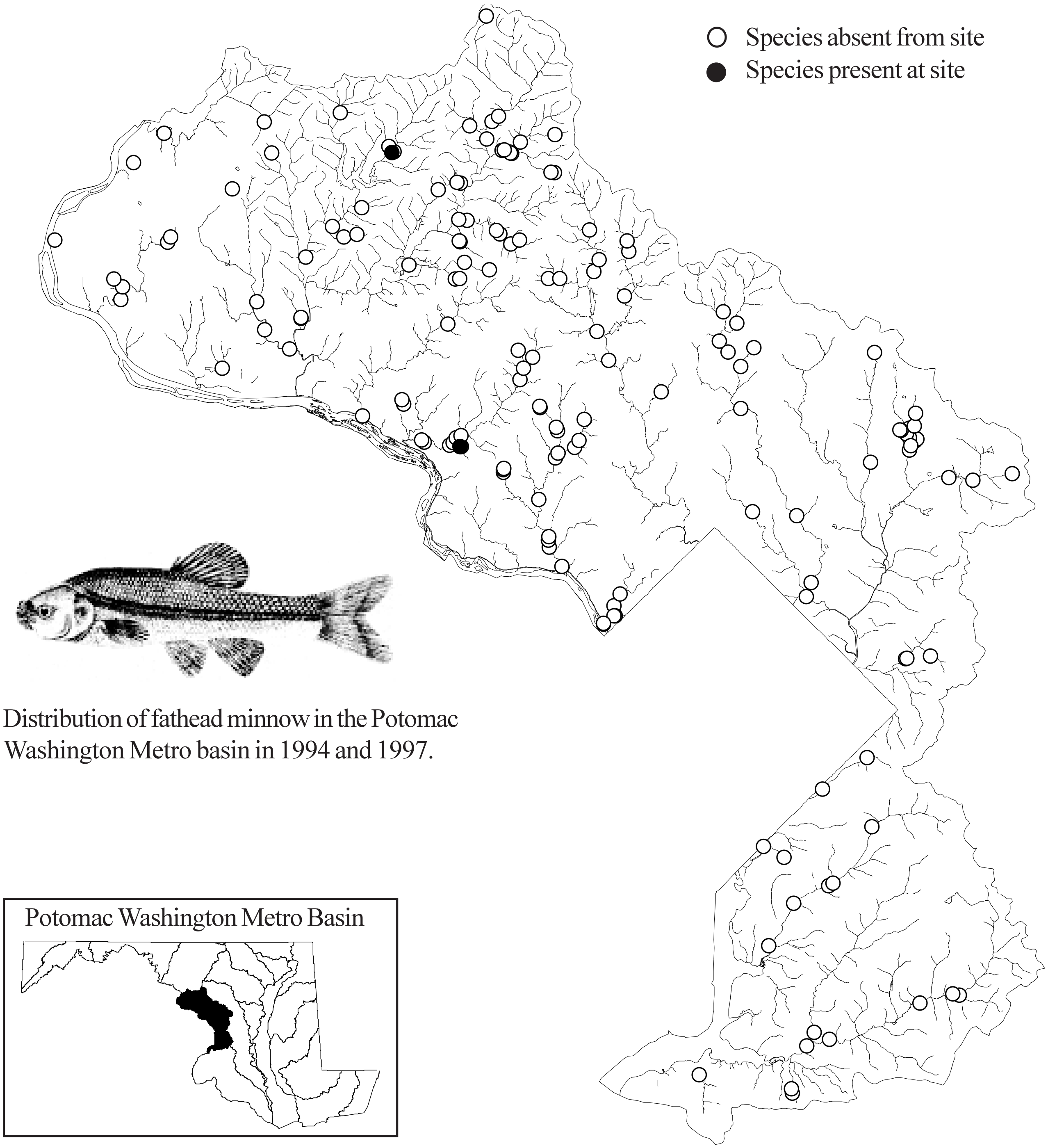
Distribution of eastern silvery minnow in the Potomac Washington Metro basin in 1994 and 1997.



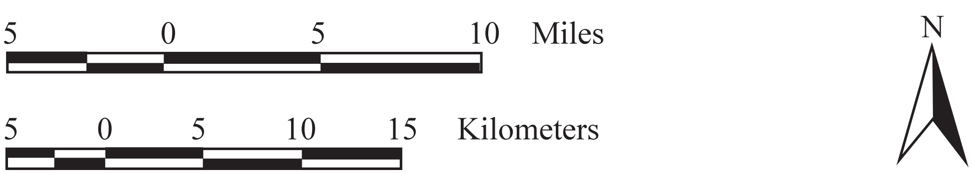


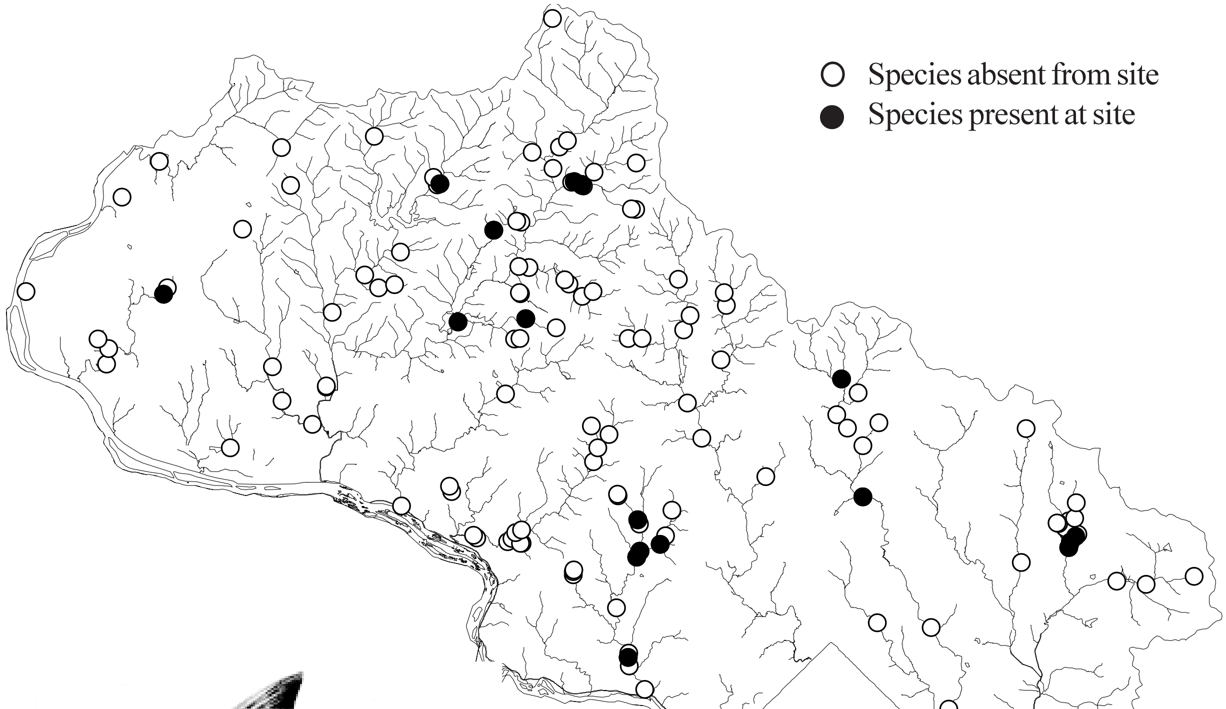
Distribution of fallfish in the Potomac Washington Metro basin in 1994 and 1997.

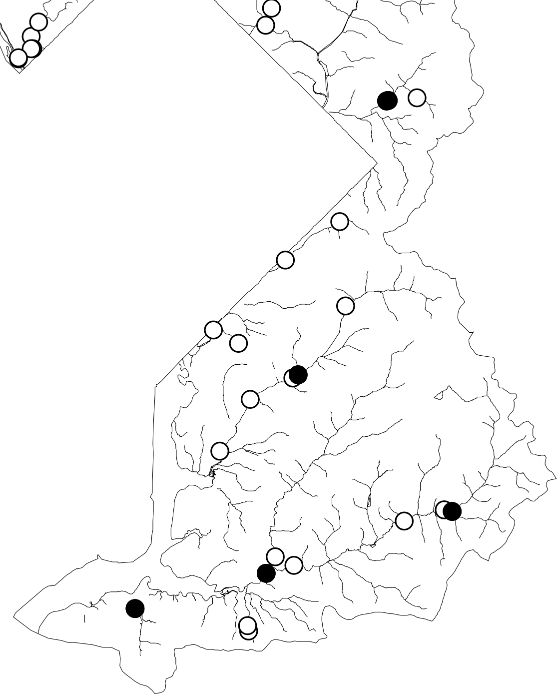


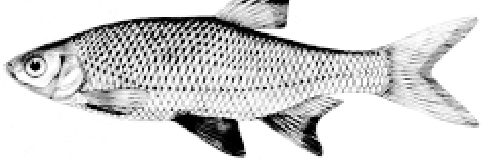


Distribution of fathead minnow in the Potomac Washington Metro basin in 1994 and 1997.

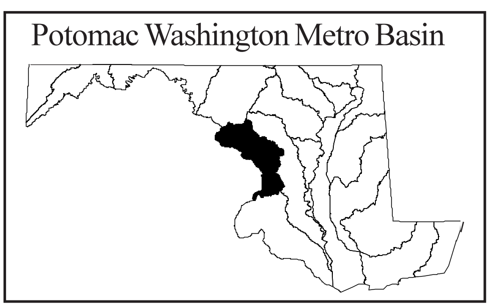


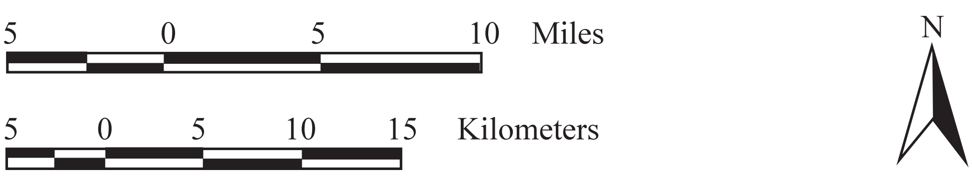


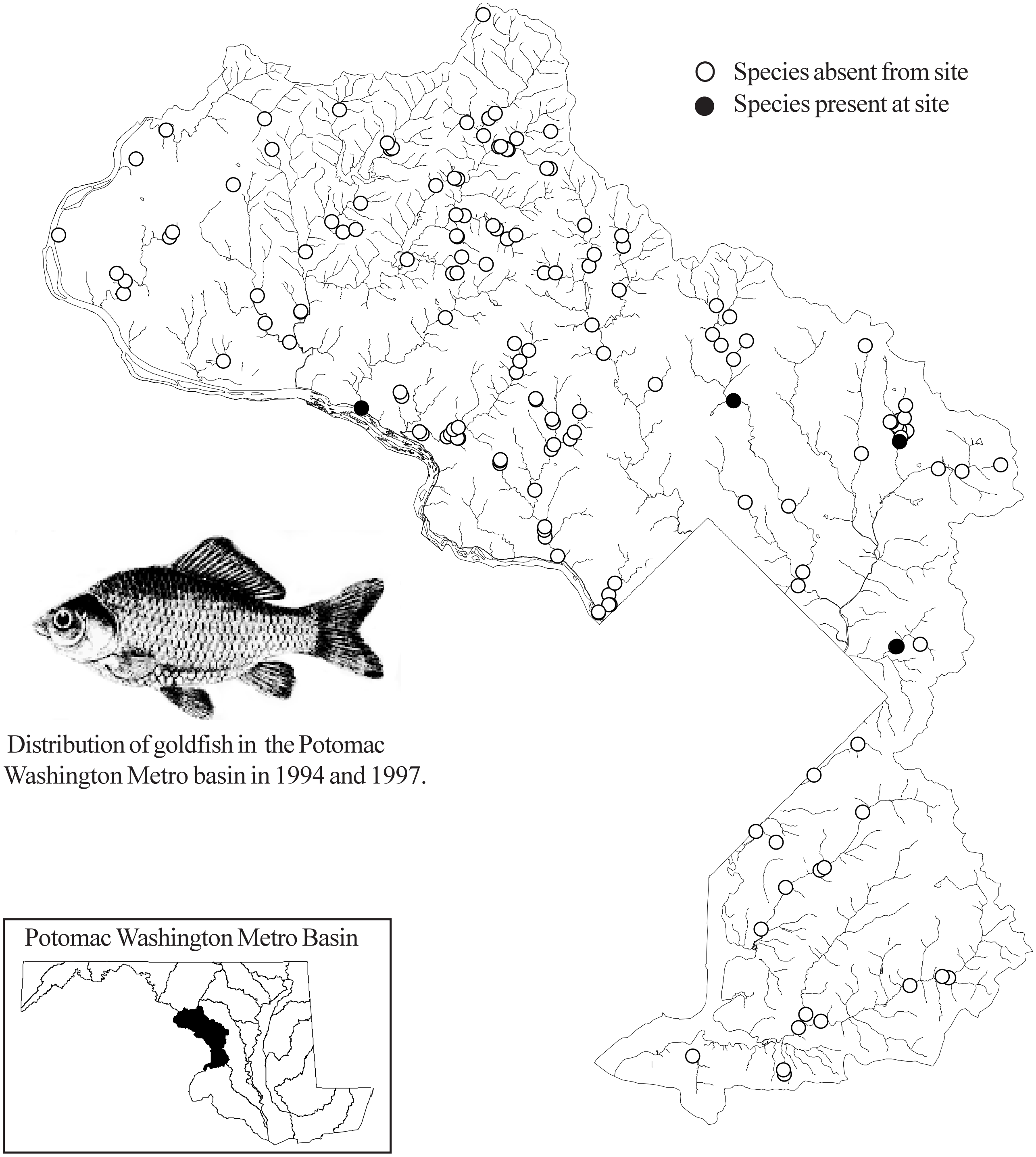




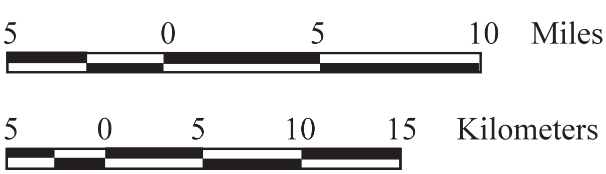
Distribution of golden shiner in the Potomac Washington Metro basin in 1994 and 1997.

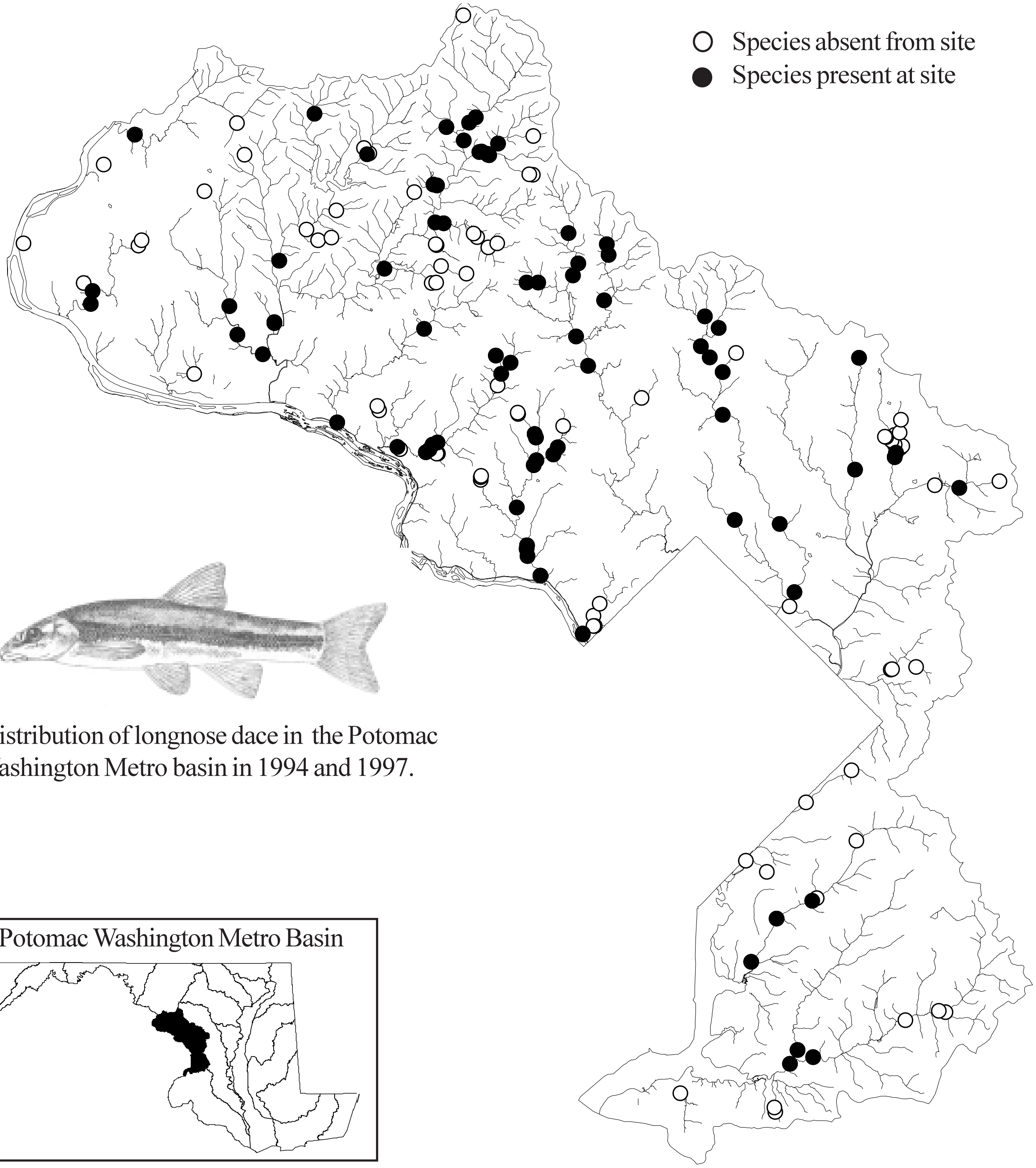




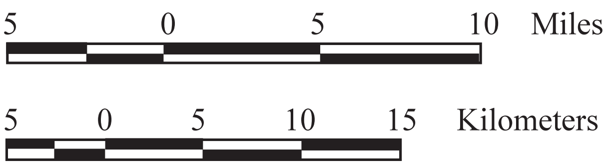


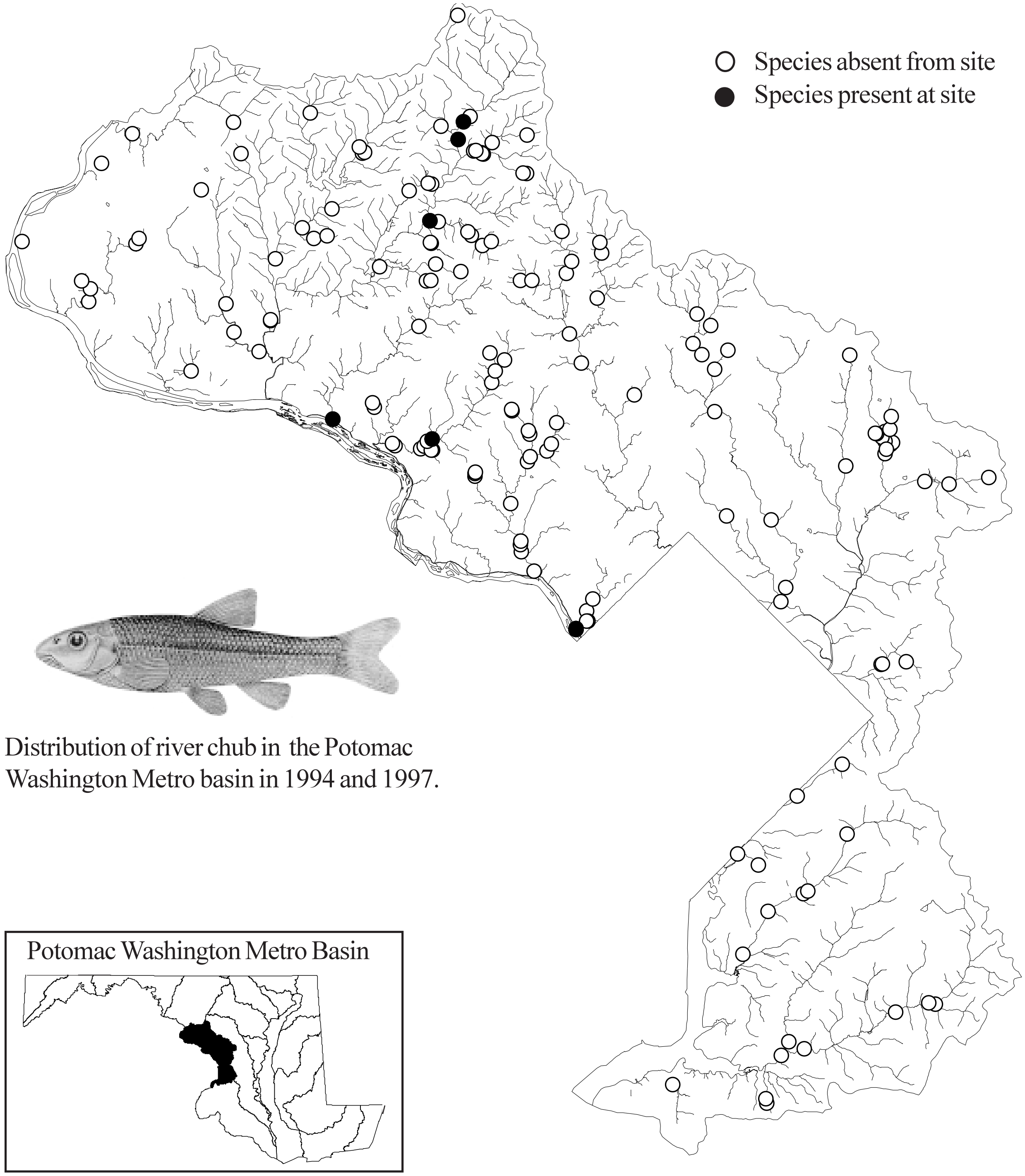
Distribution of goldfish in the Potomac Washington Metro basin in 1994 and 1997.



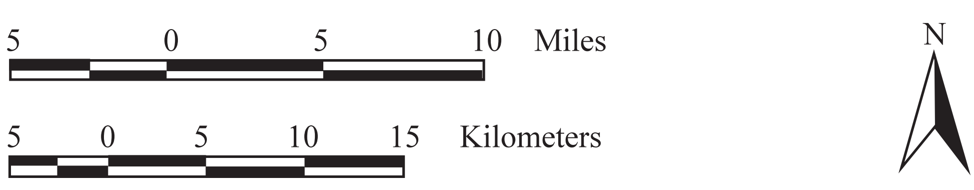


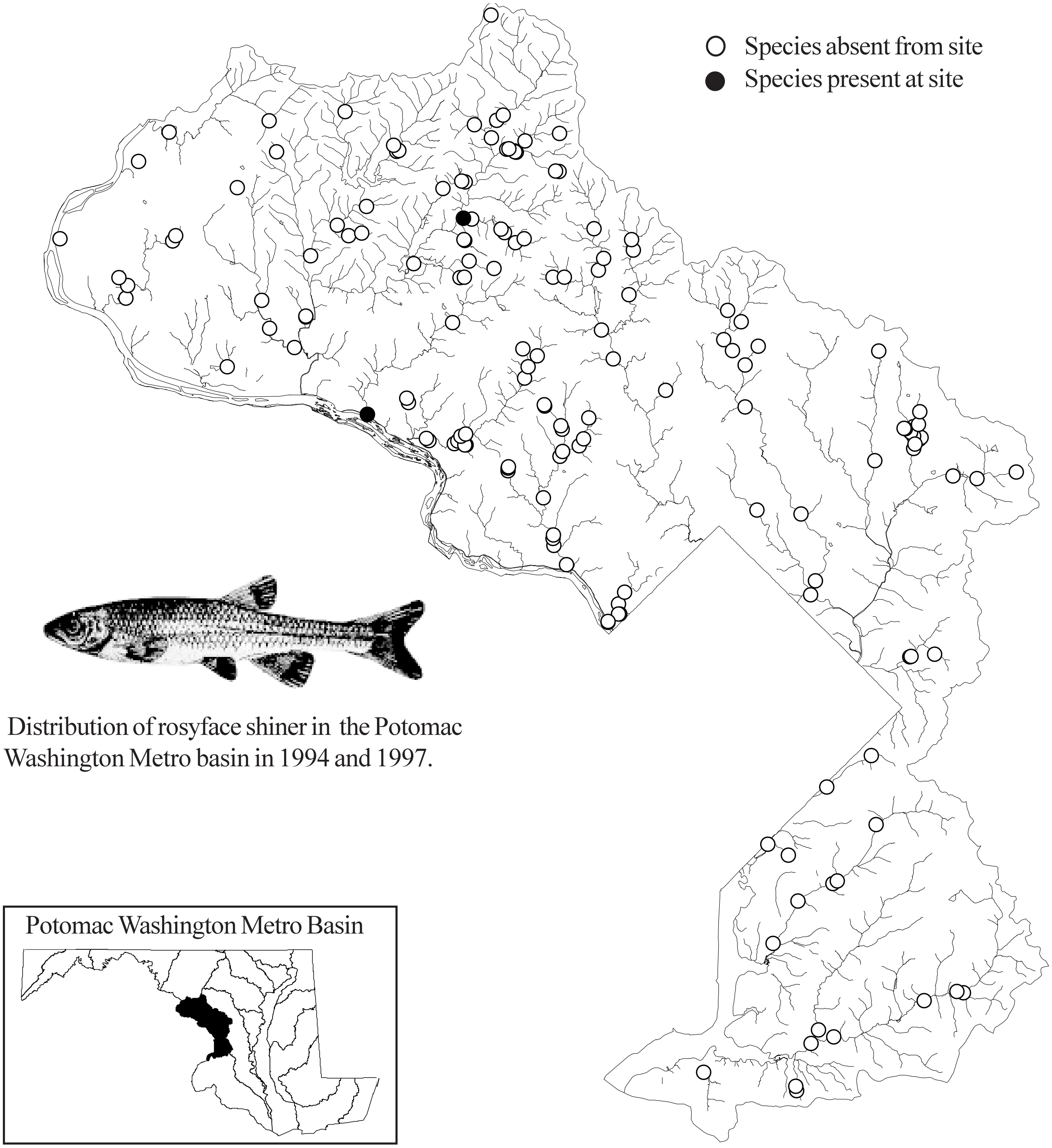
Distribution of longnose dace in the Potomac Washington Metro basin in 1994 and 1997.



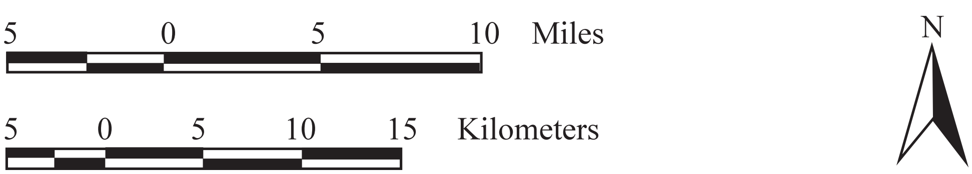


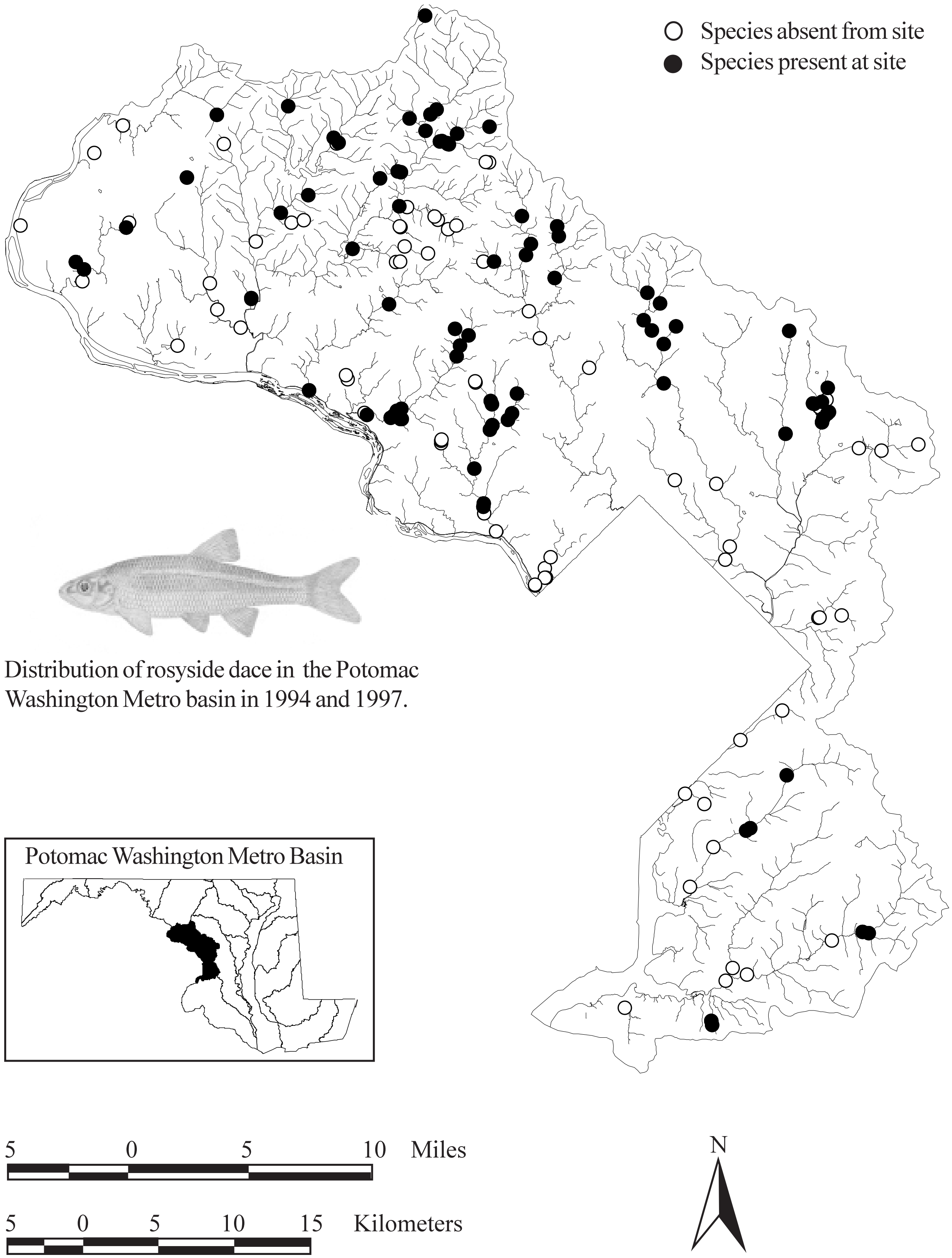
Distribution of river chub in the Potomac Washington Metro basin in 1994 and 1997.



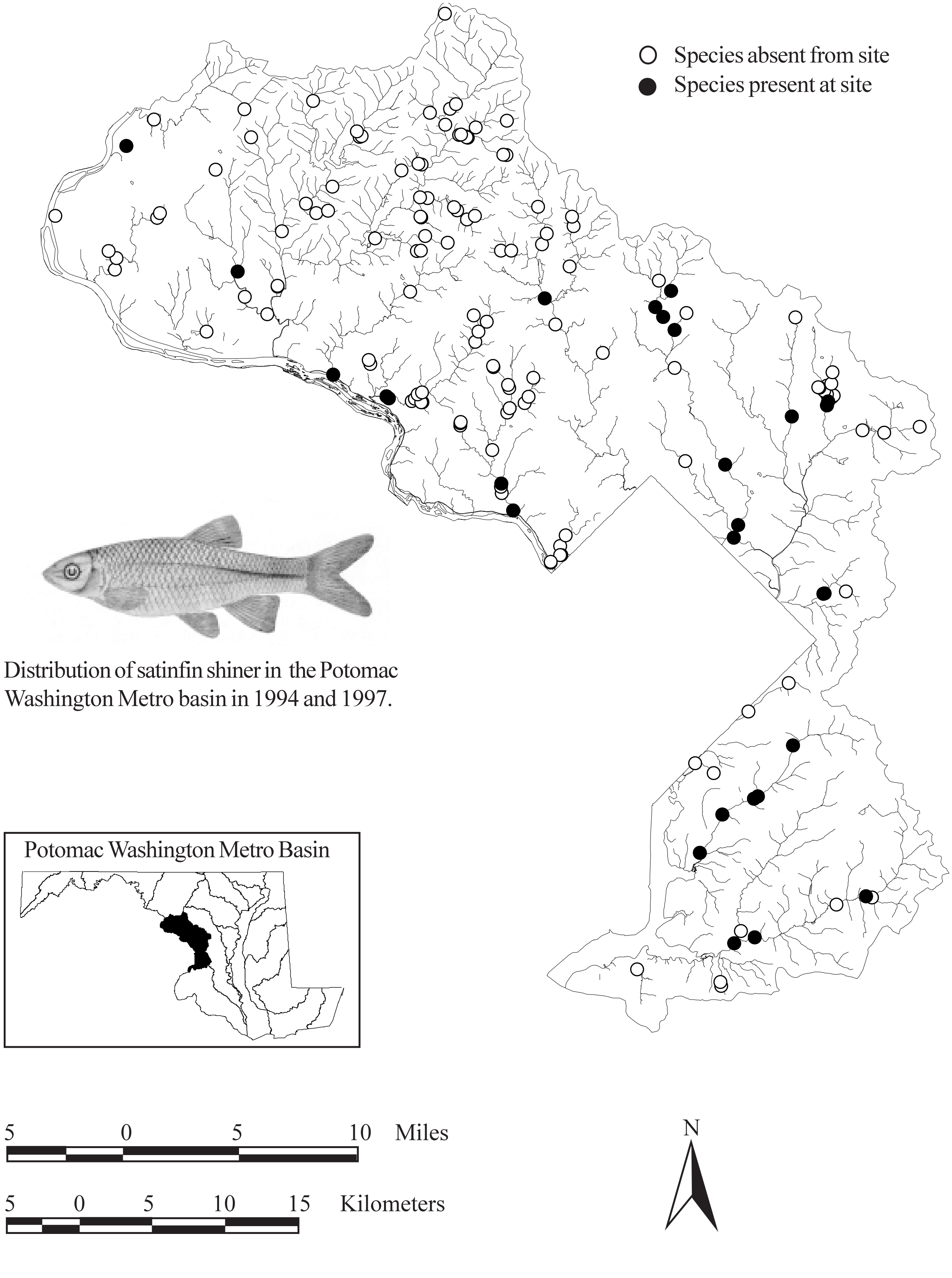


Distribution of rosyface shiner in the Potomac Washington Metro basin in 1994 and 1997.

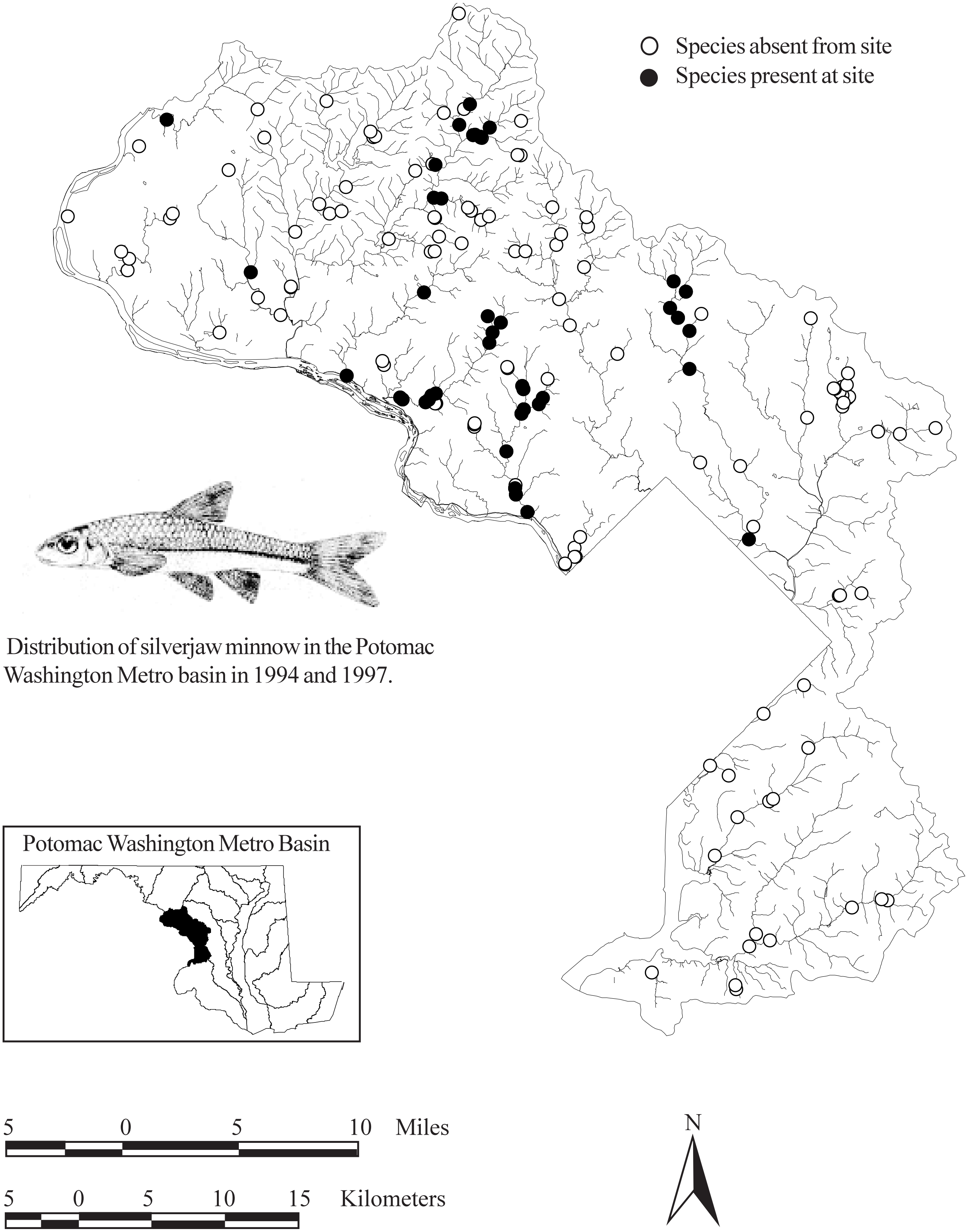




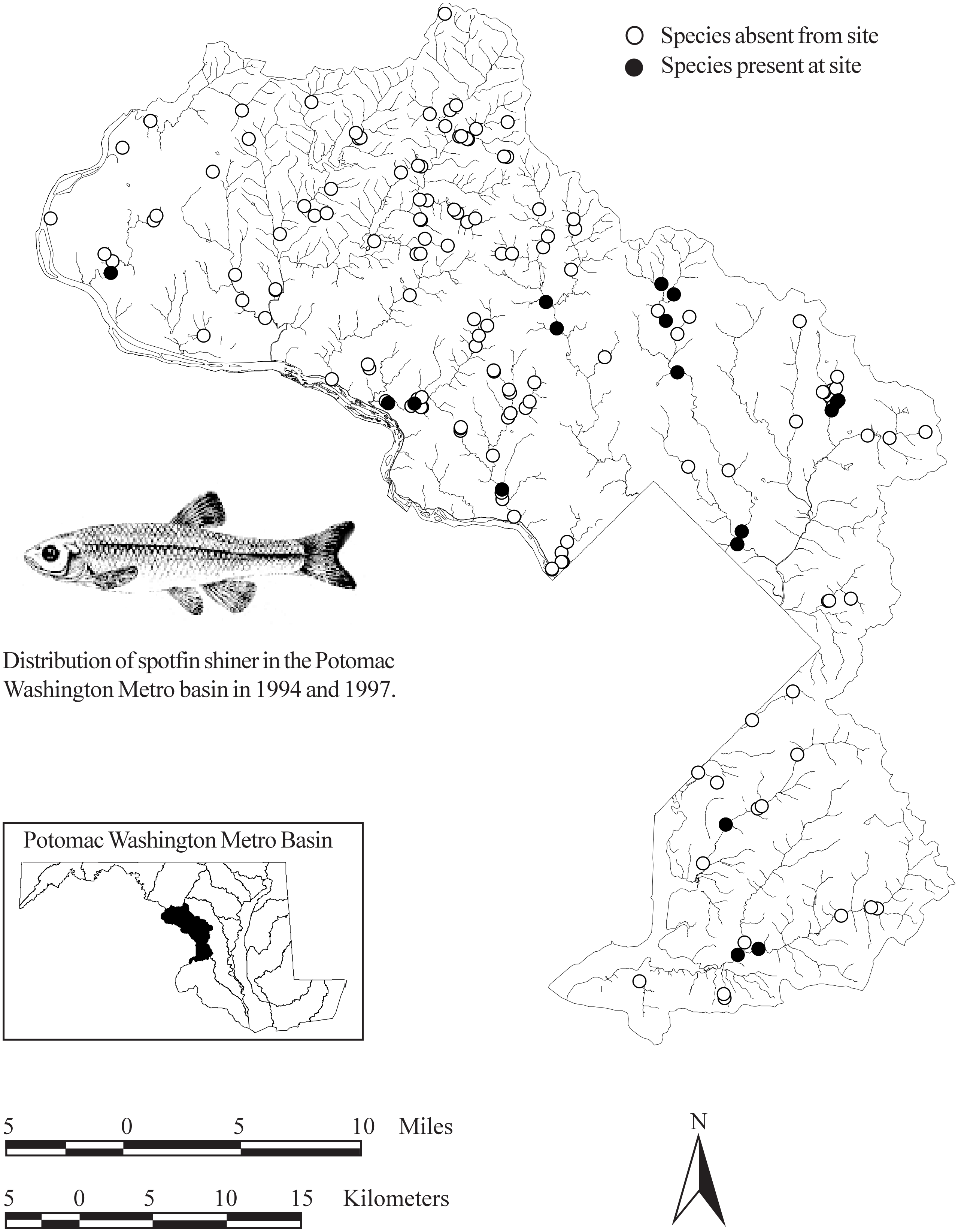
Distribution of rosyside dace in the Potomac Washington Metro basin in 1994 and 1997.



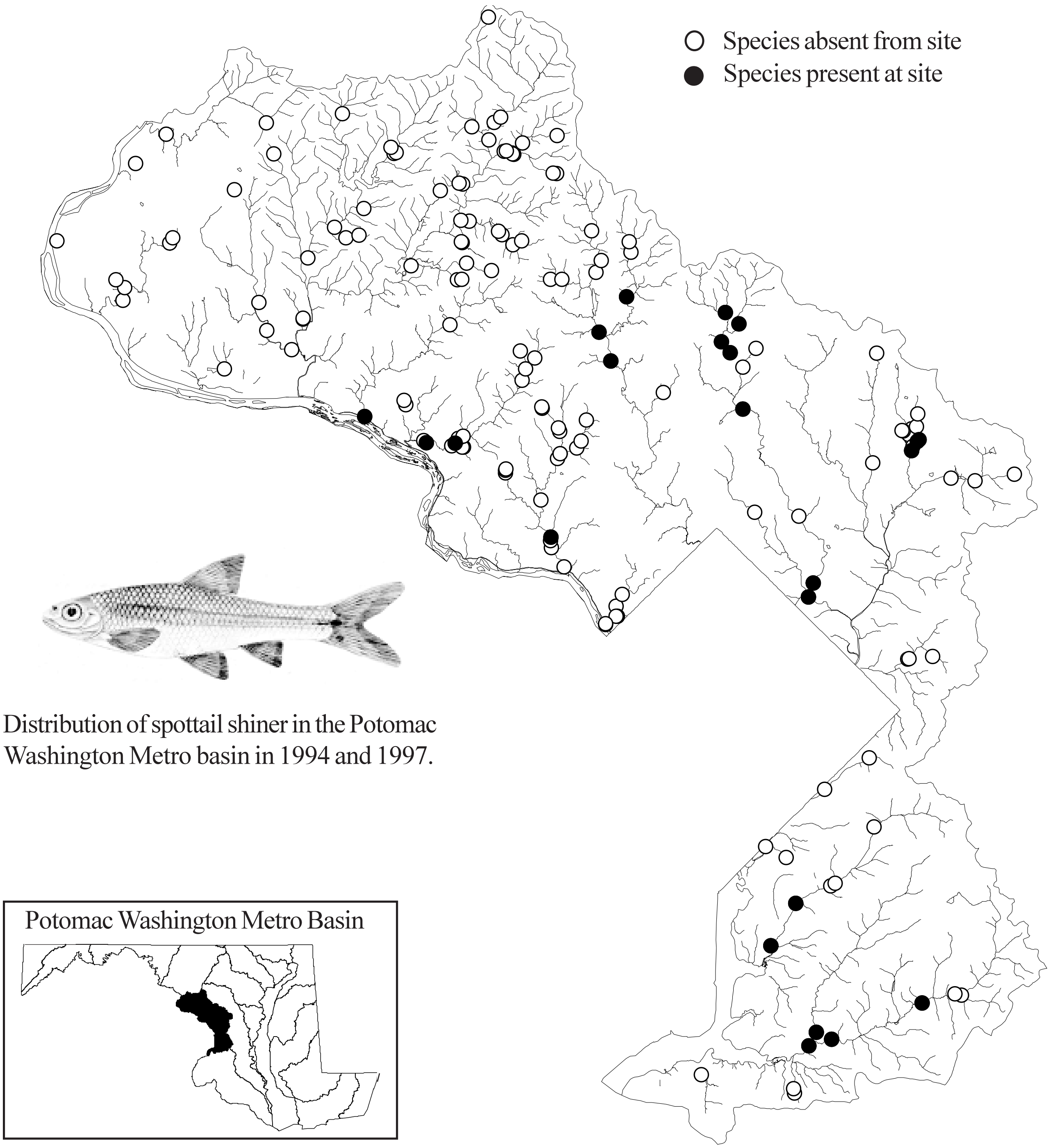
Distribution of satinfin shiner in the Potomac Washington Metro basin in 1994 and 1997.



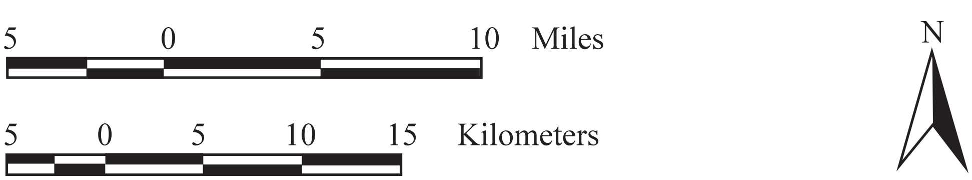
Distribution of silverjaw minnow in the Potomac Washington Metro basin in 1994 and 1997.

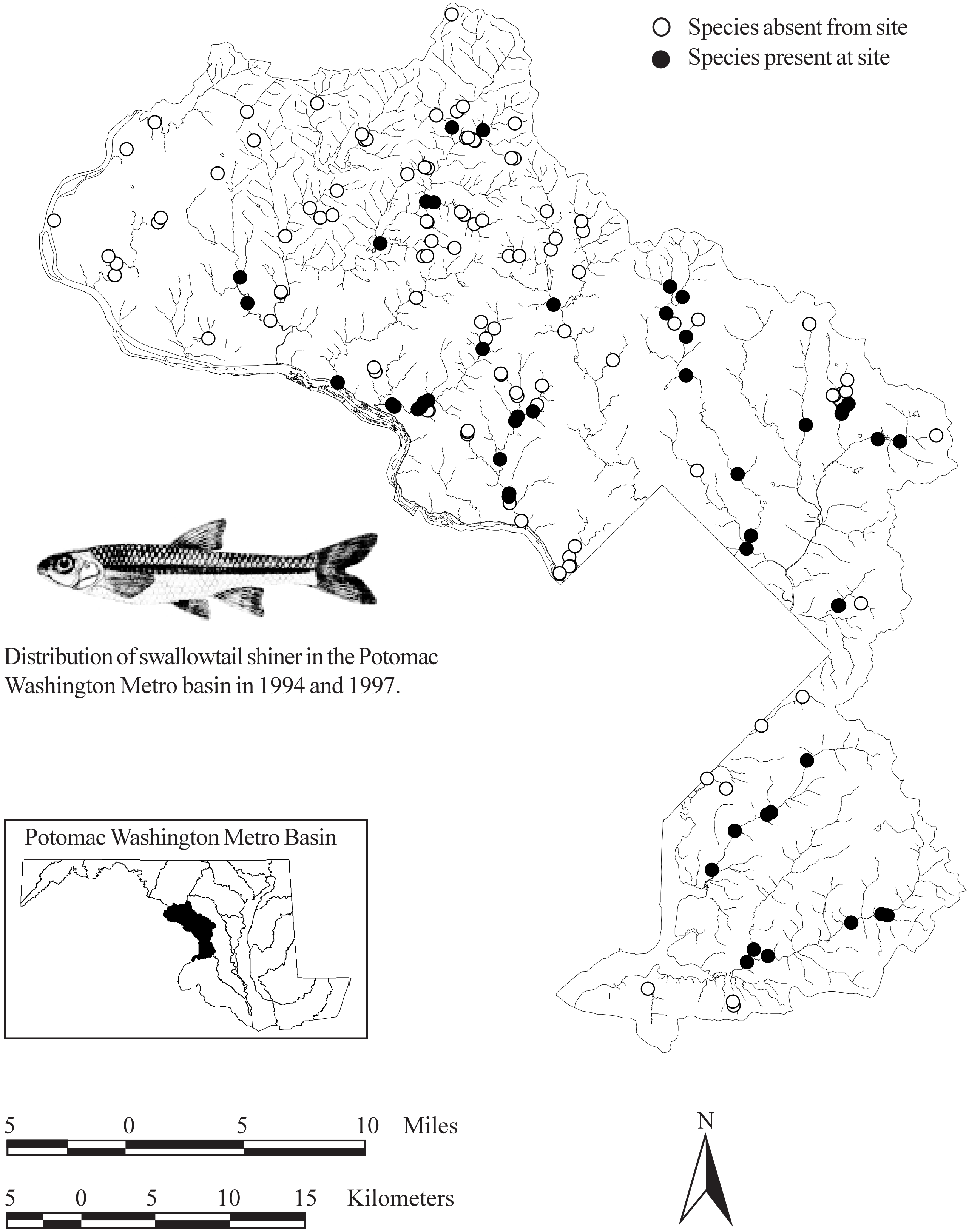


Distribution of spotfin shiner in the Potomac Washington Metro basin in 1994 and 1997.

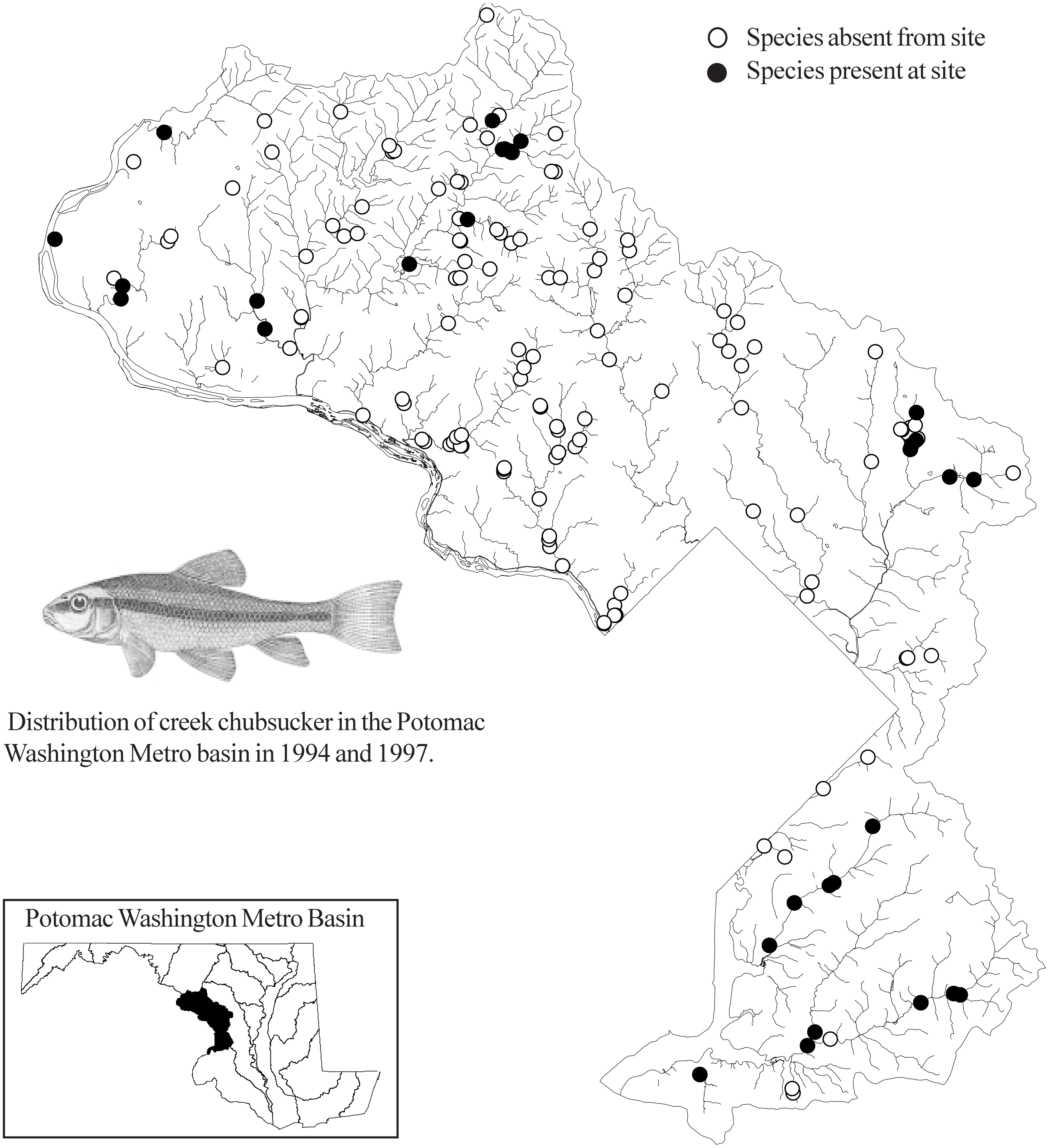


Distribution of spottail shiner in the Potomac Washington Metro basin in 1994 and 1997.

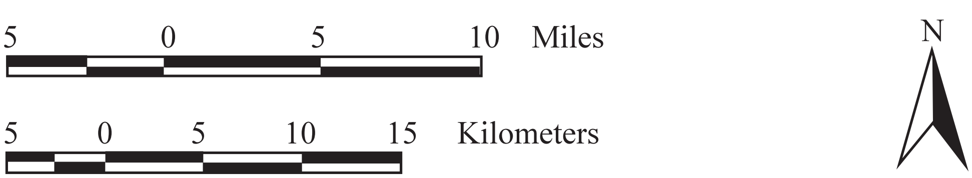


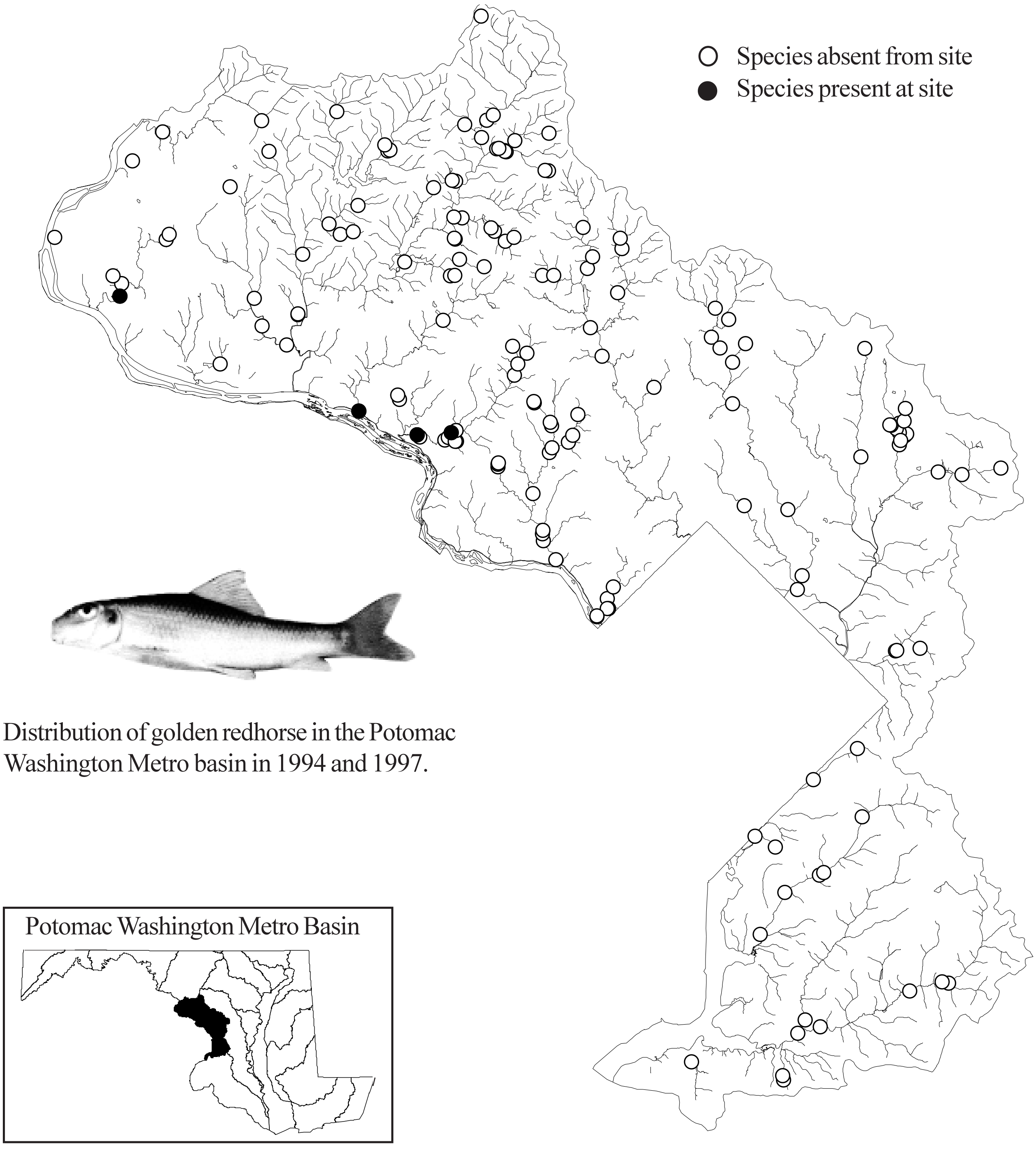


Distribution of swallowtail shiner in the Potomac Washington Metro basin in 1994 and 1997.

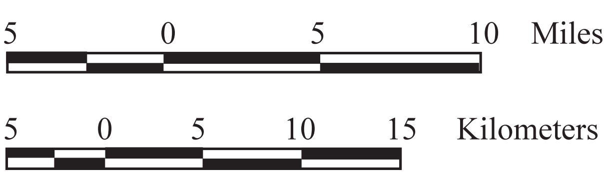


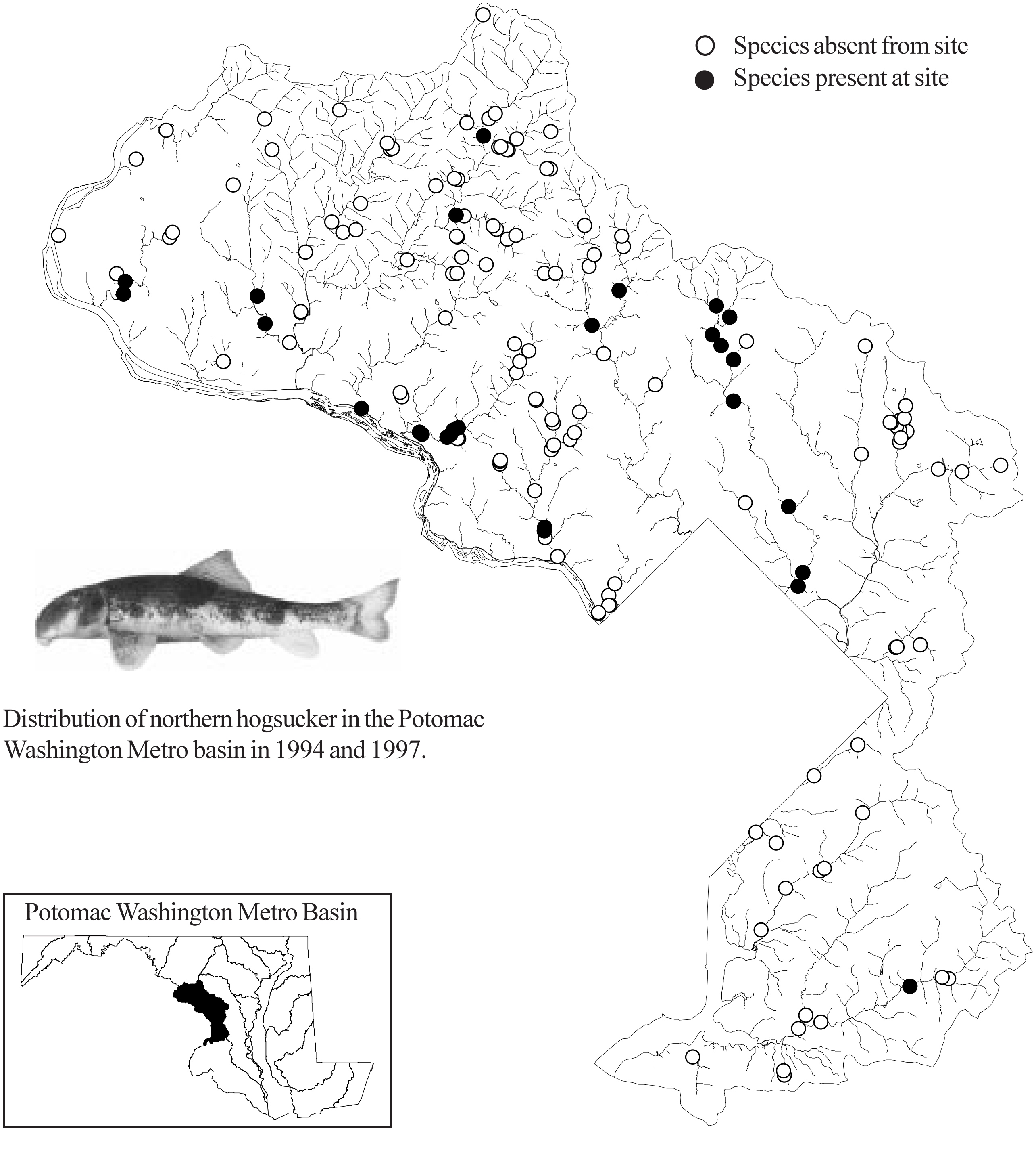
Distribution of creek chubsucker in the Potomac Washington Metro basin in 1994 and 1997.



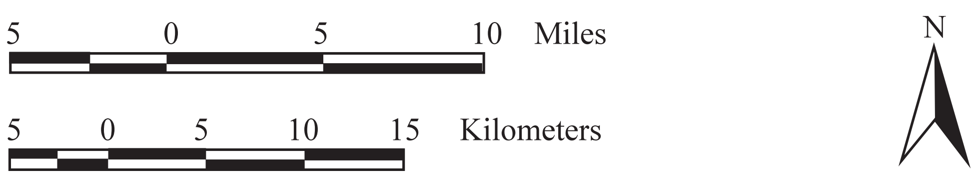


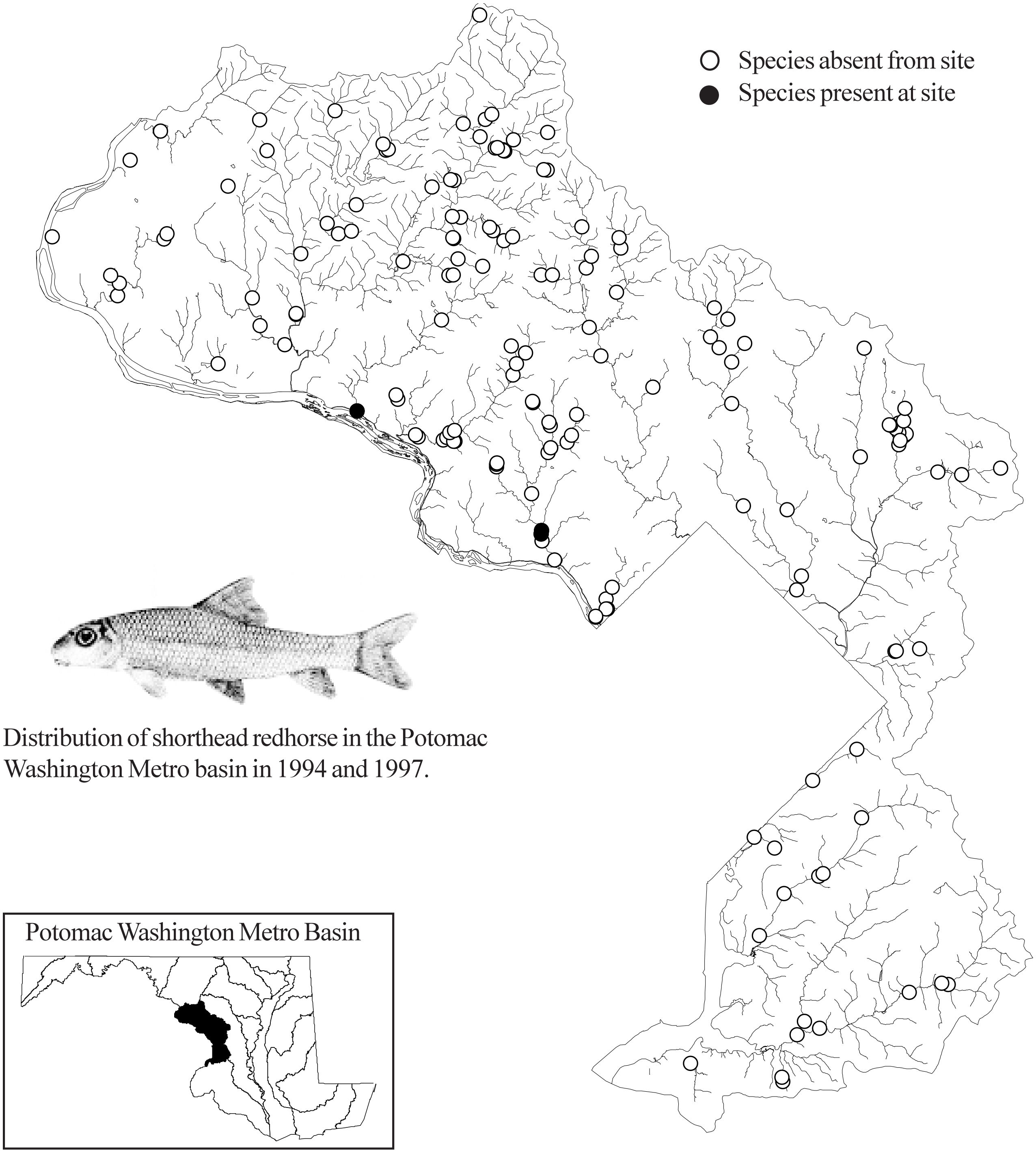
Distribution of golden redhorse in the Potomac Washington Metro basin in 1994 and 1997.



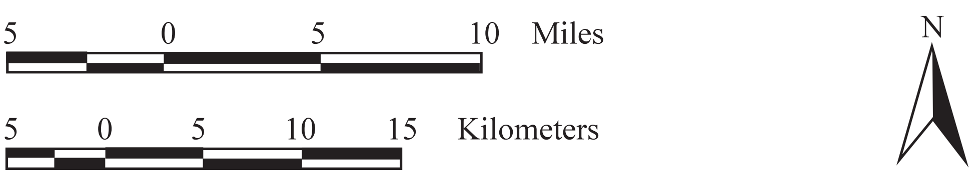


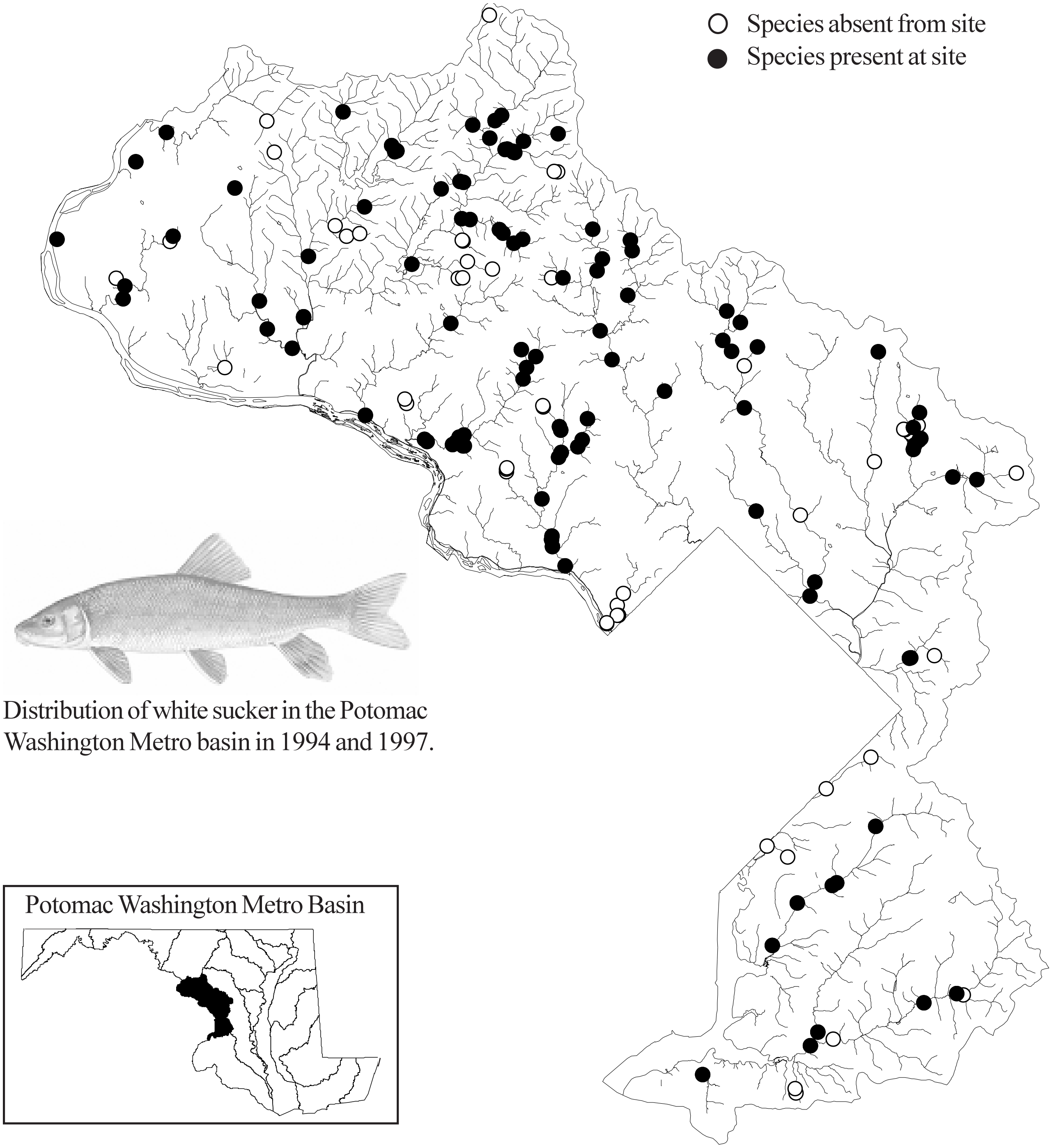
Distribution of northern hogsucker in the Potomac Washington Metro basin in 1994 and 1997.



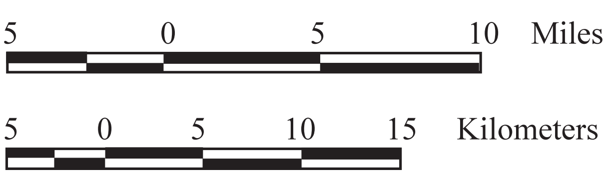


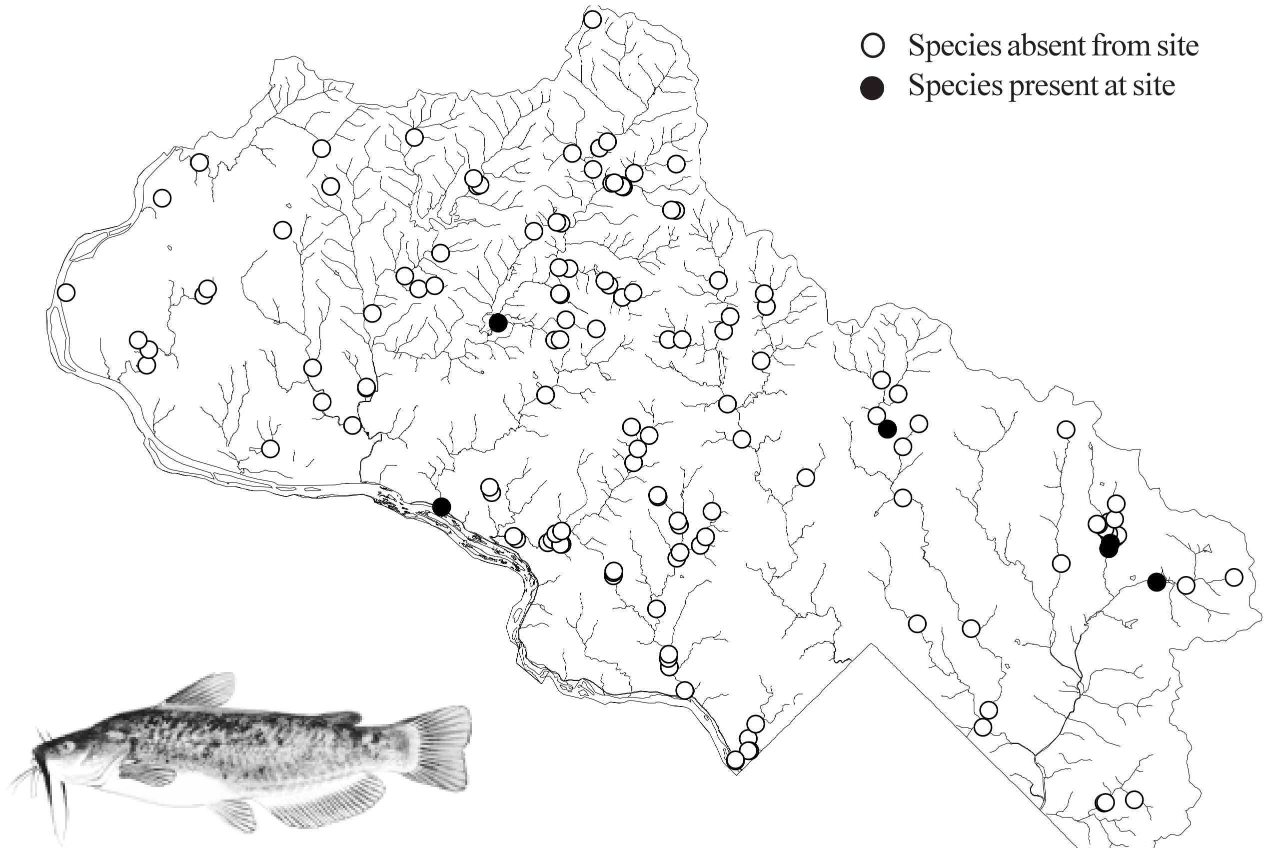
Distribution of shorthead redhorse in the Potomac Washington Metro basin in 1994 and 1997.

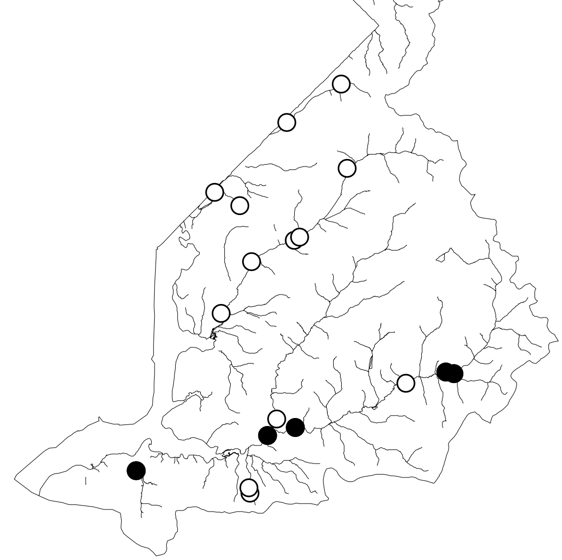




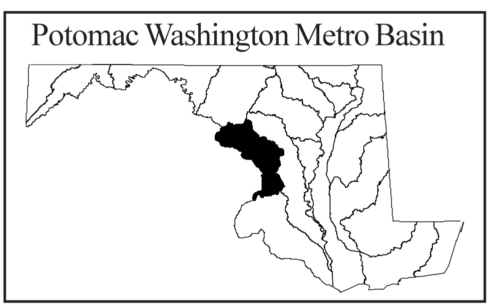
Distribution of white sucker in the Potomac Washington Metro basin in 1994 and 1997.

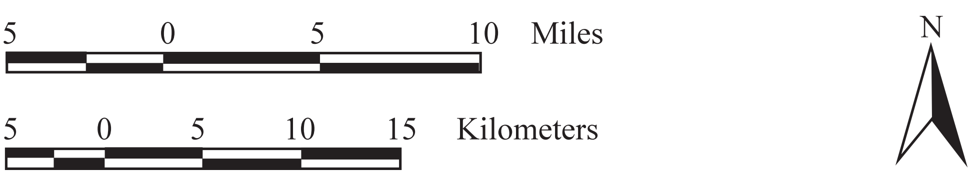


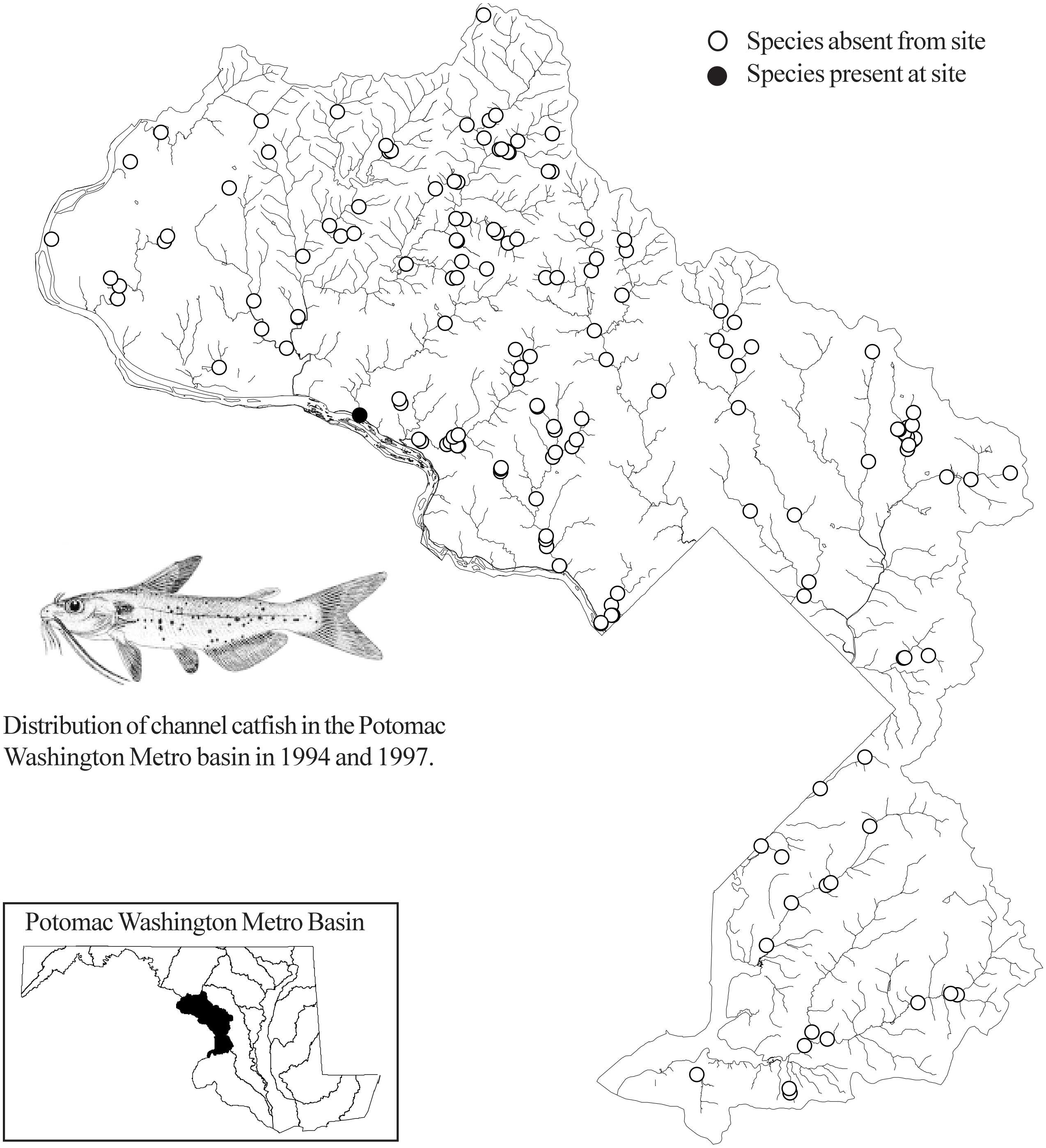




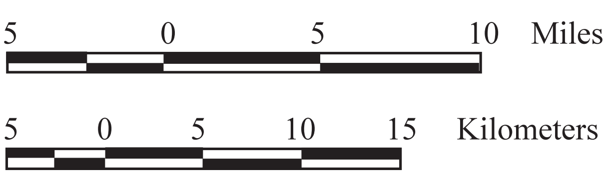
Distribution of brown bullhead in the Potomac Washington Metro basin in 1994 and 1997.

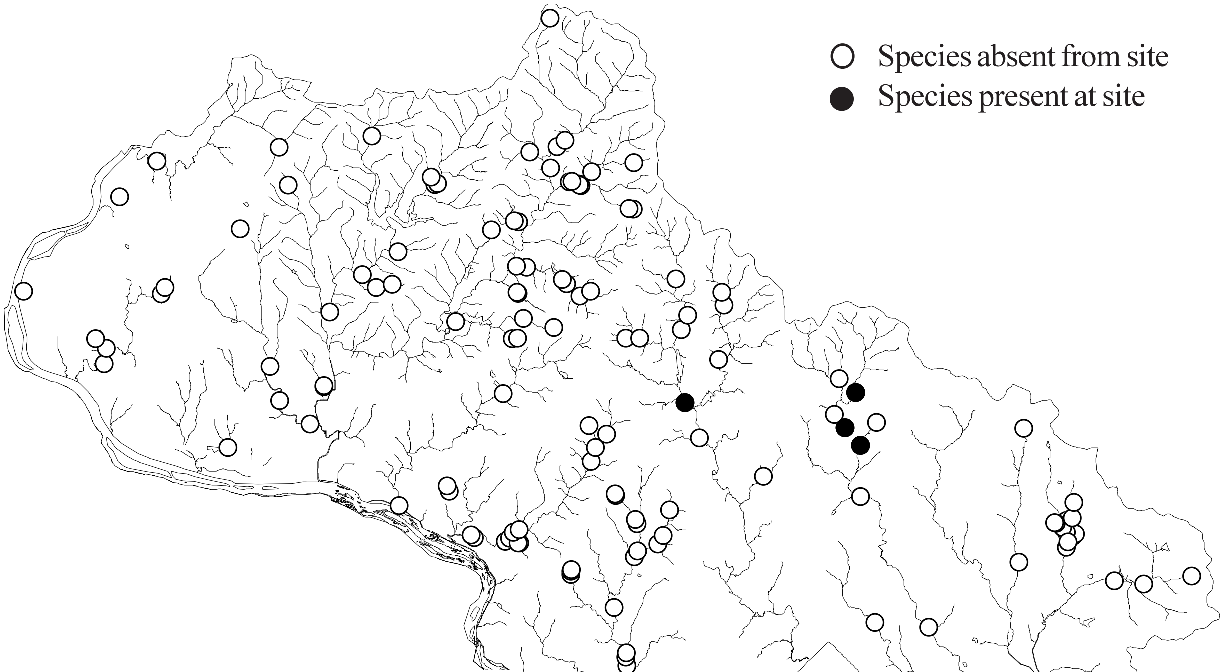


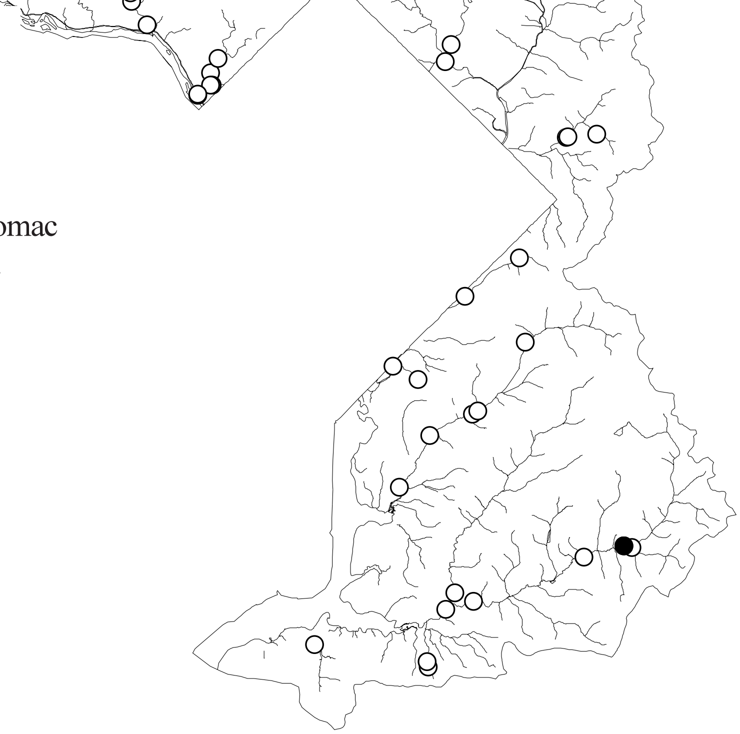


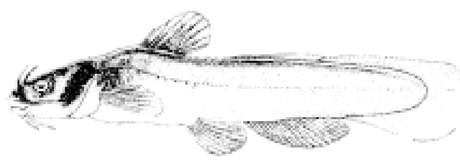


Distribution of channel catfish in the Potomac Washington Metro basin in 1994 and 1997.

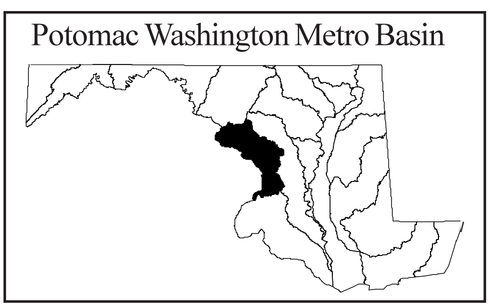


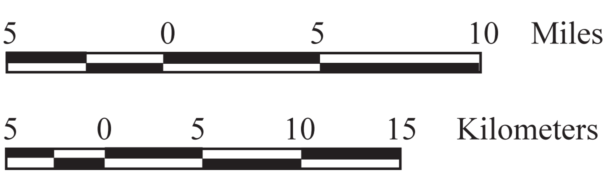


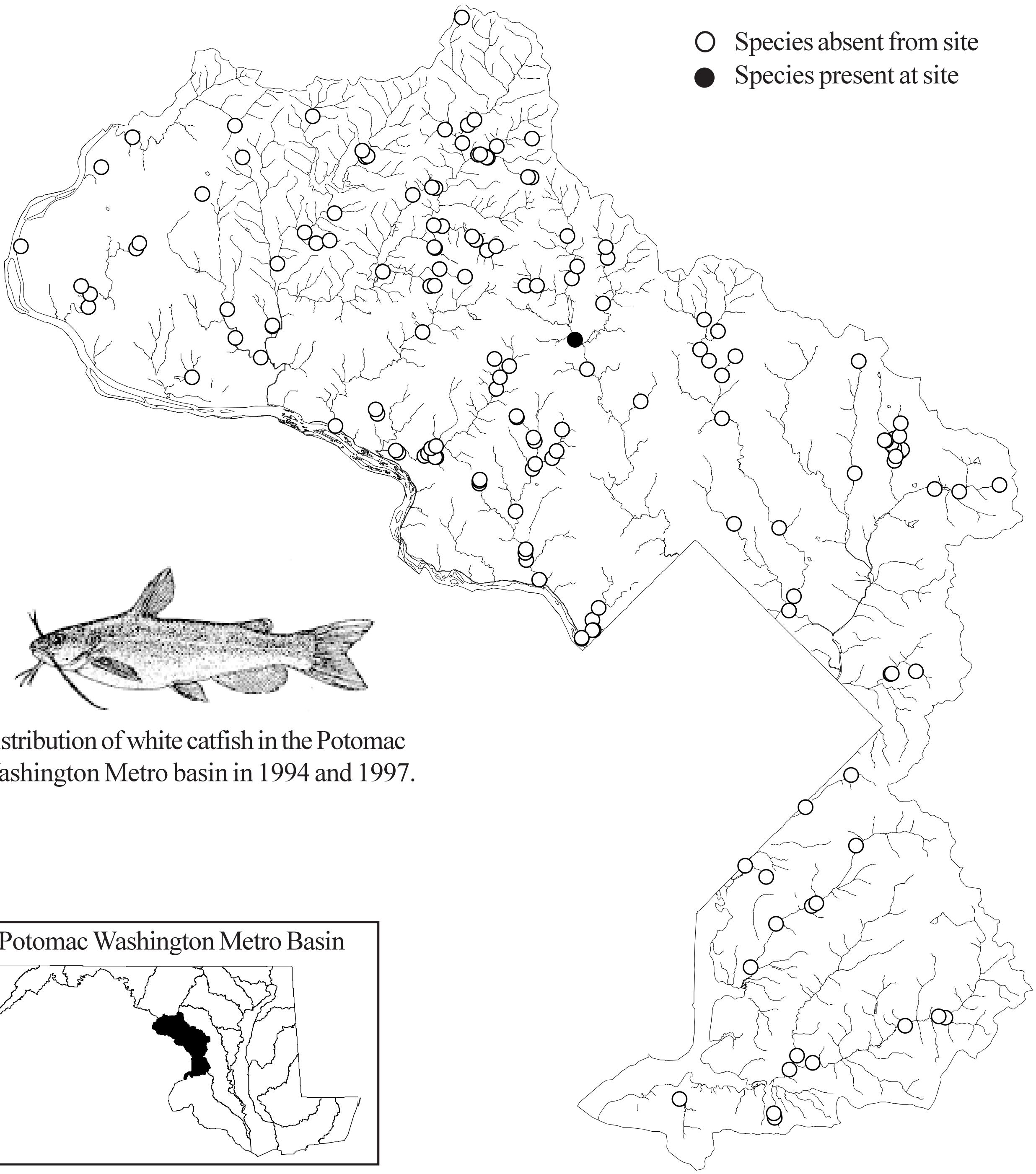




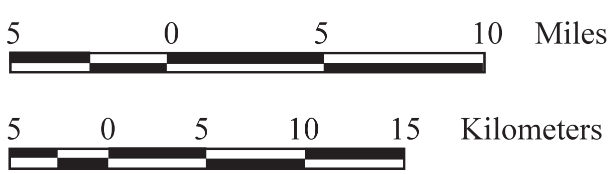
Distribution of margined madtom in the Potomac Washington Metro basin in 1994 and 1997.

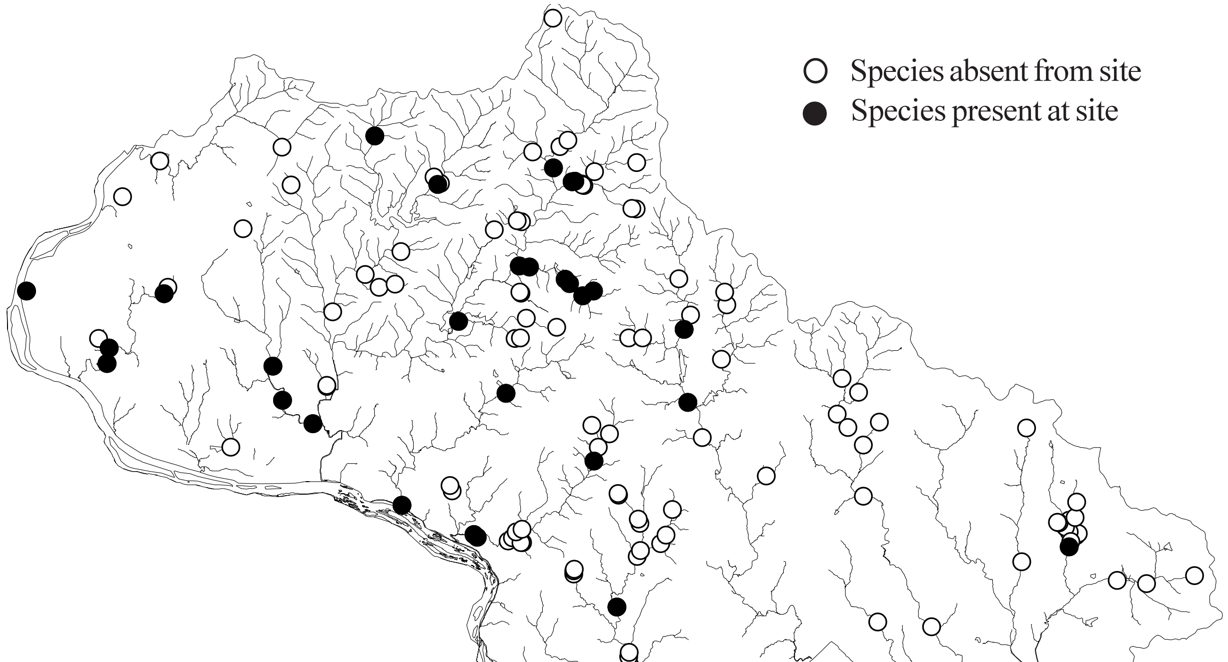


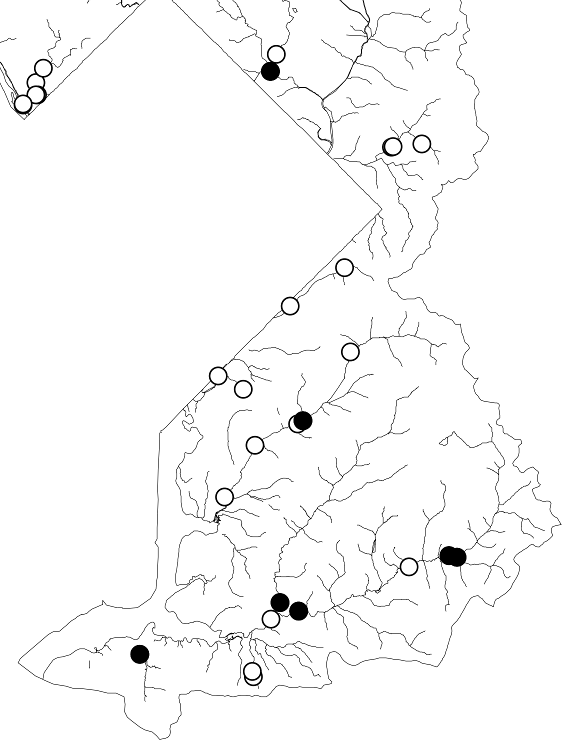


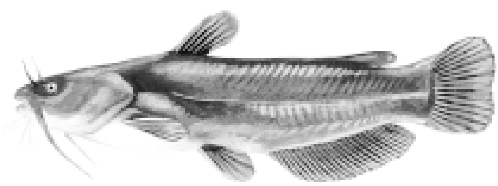


Distribution of white catfish in the Potomac Washington Metro basin in 1994 and 1997.

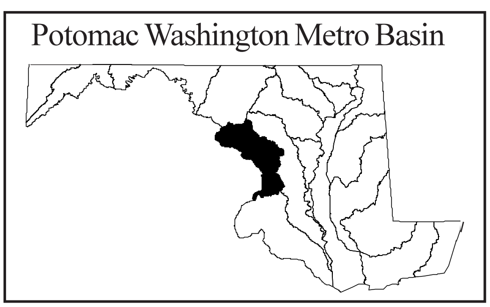


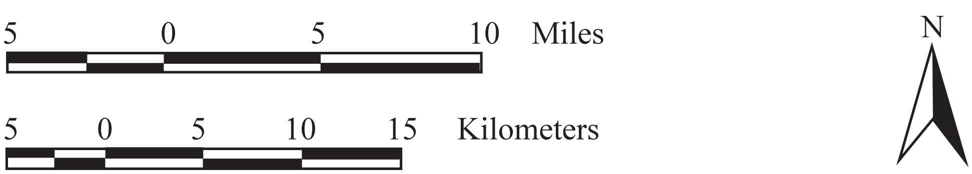


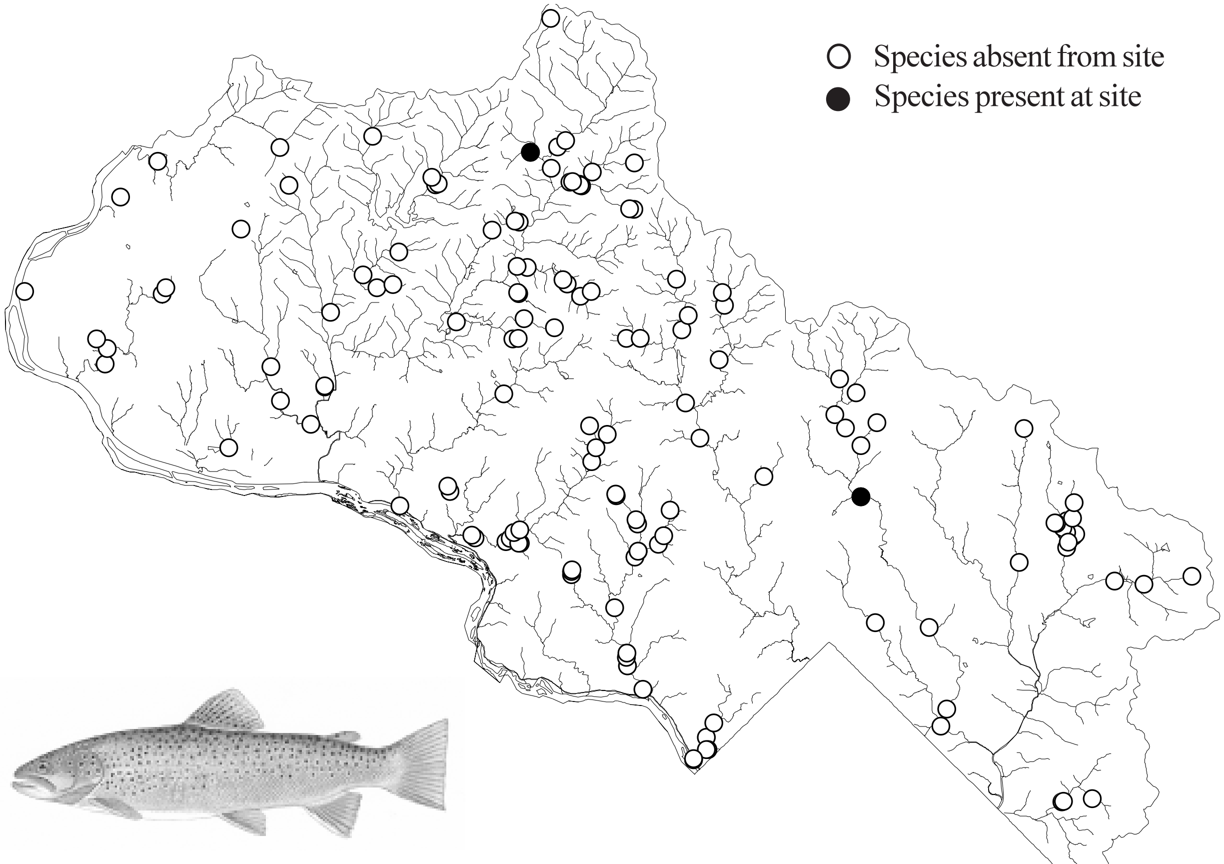




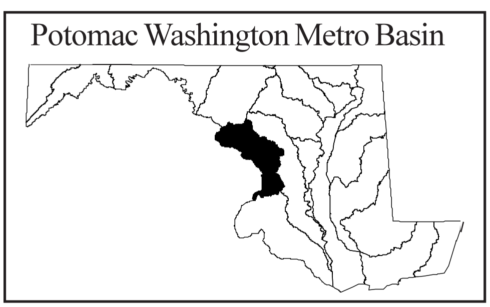
Distribution of yellow bullhead in the Potomac Washington Metro basin in 1994 and 1997.

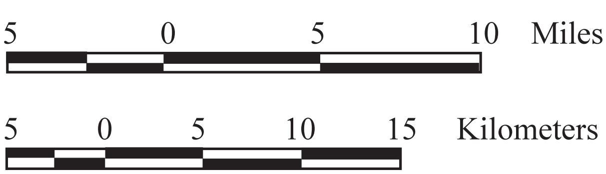


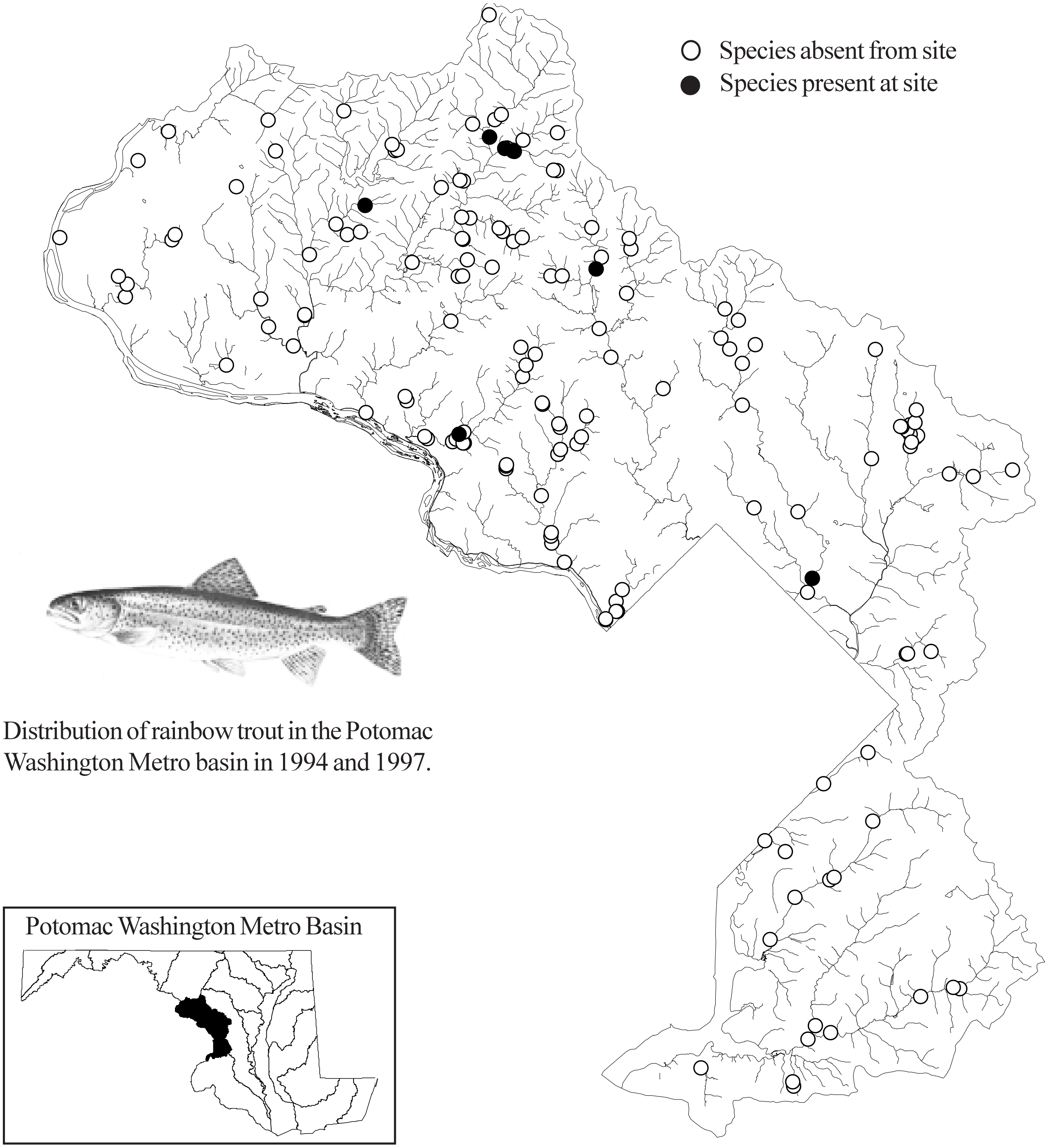




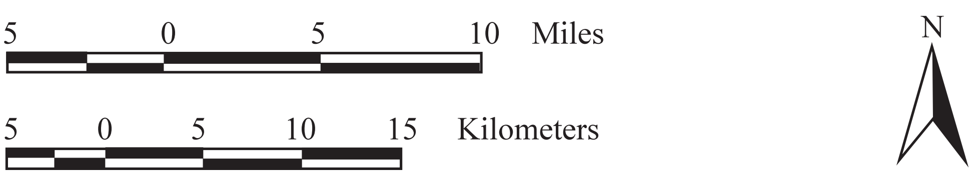
Distribution of brown trout in the Potomac Washington Metro basin in 1994 and 1997.

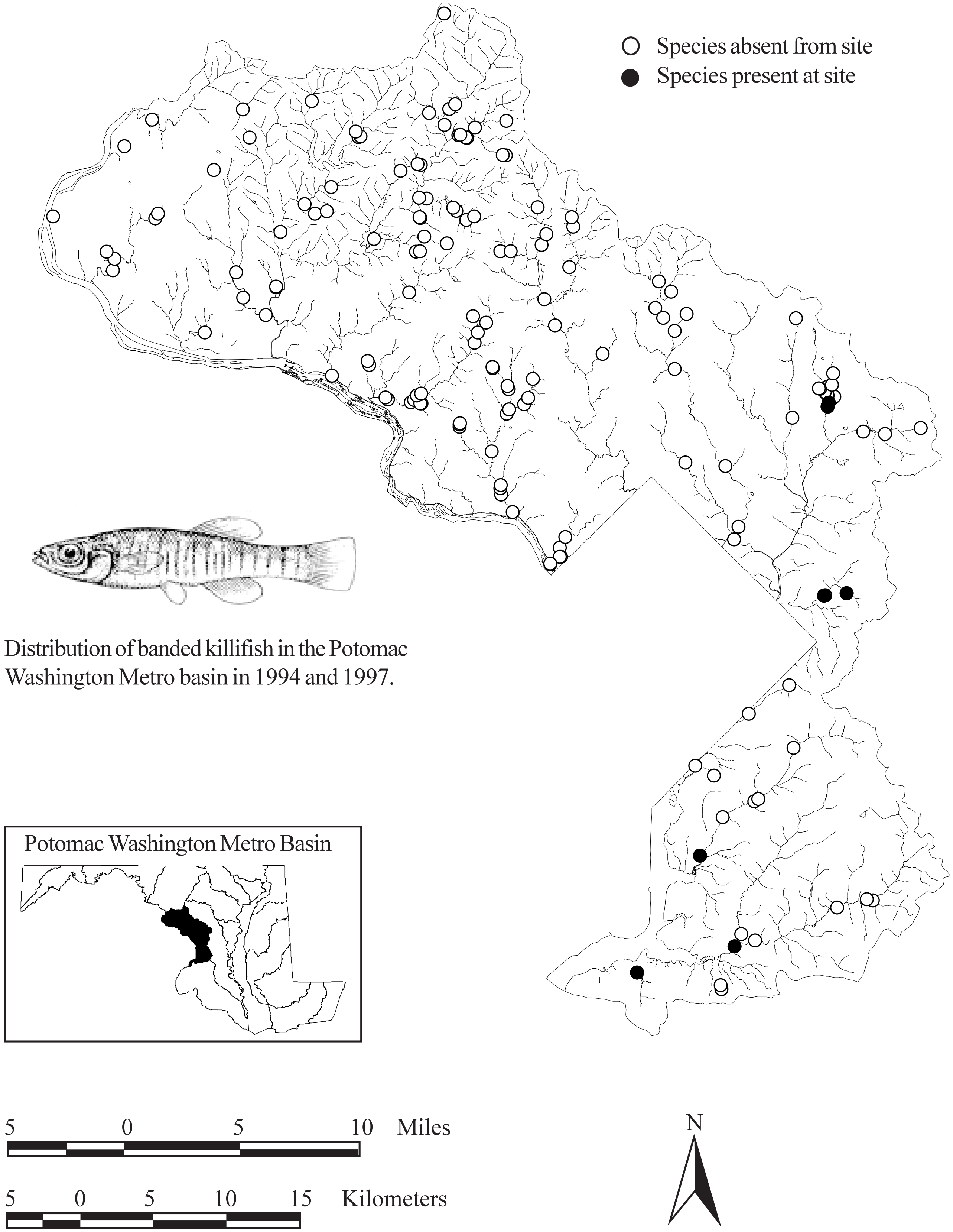




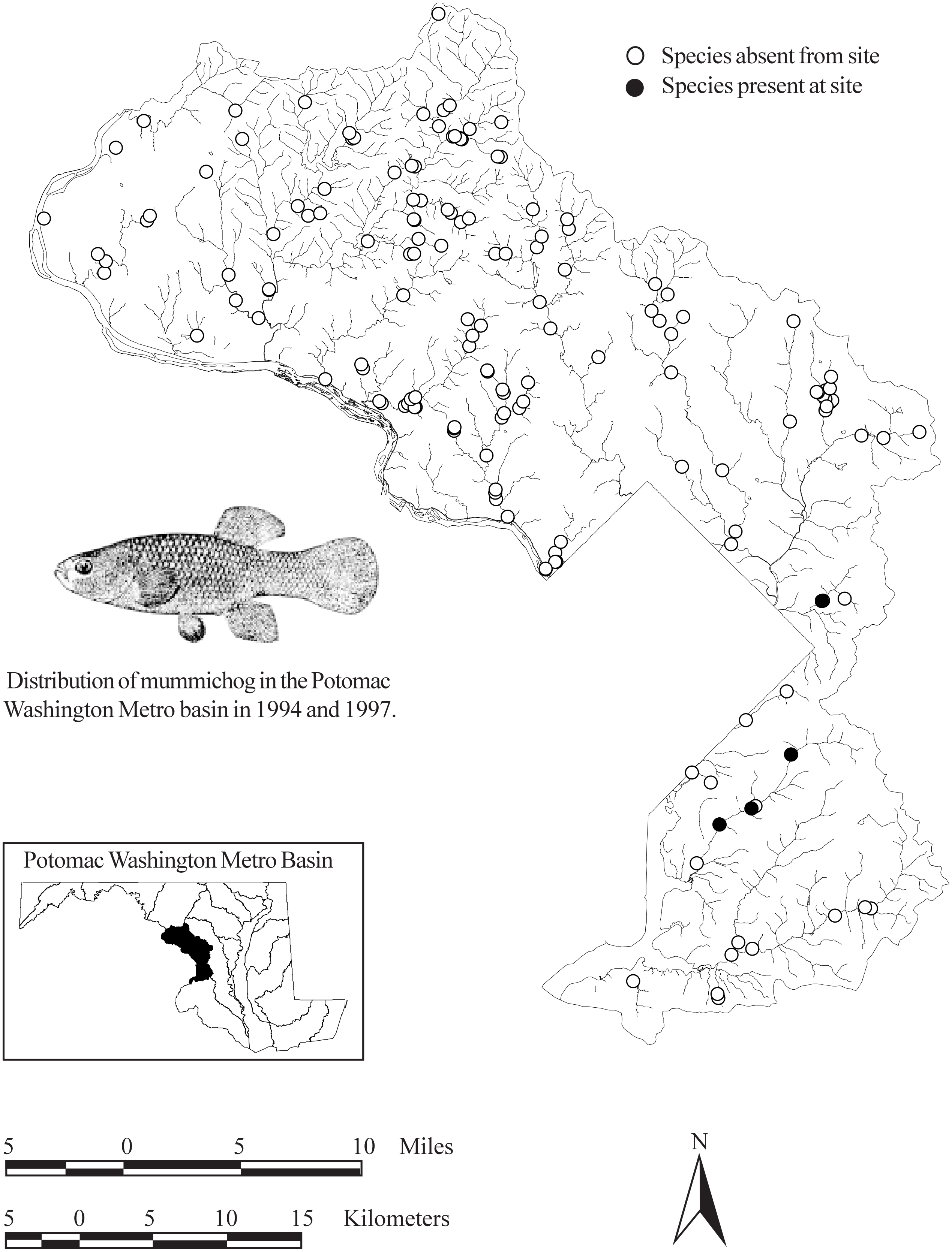


Distribution of rainbow trout in the Potomac Washington Metro basin in 1994 and 1997.

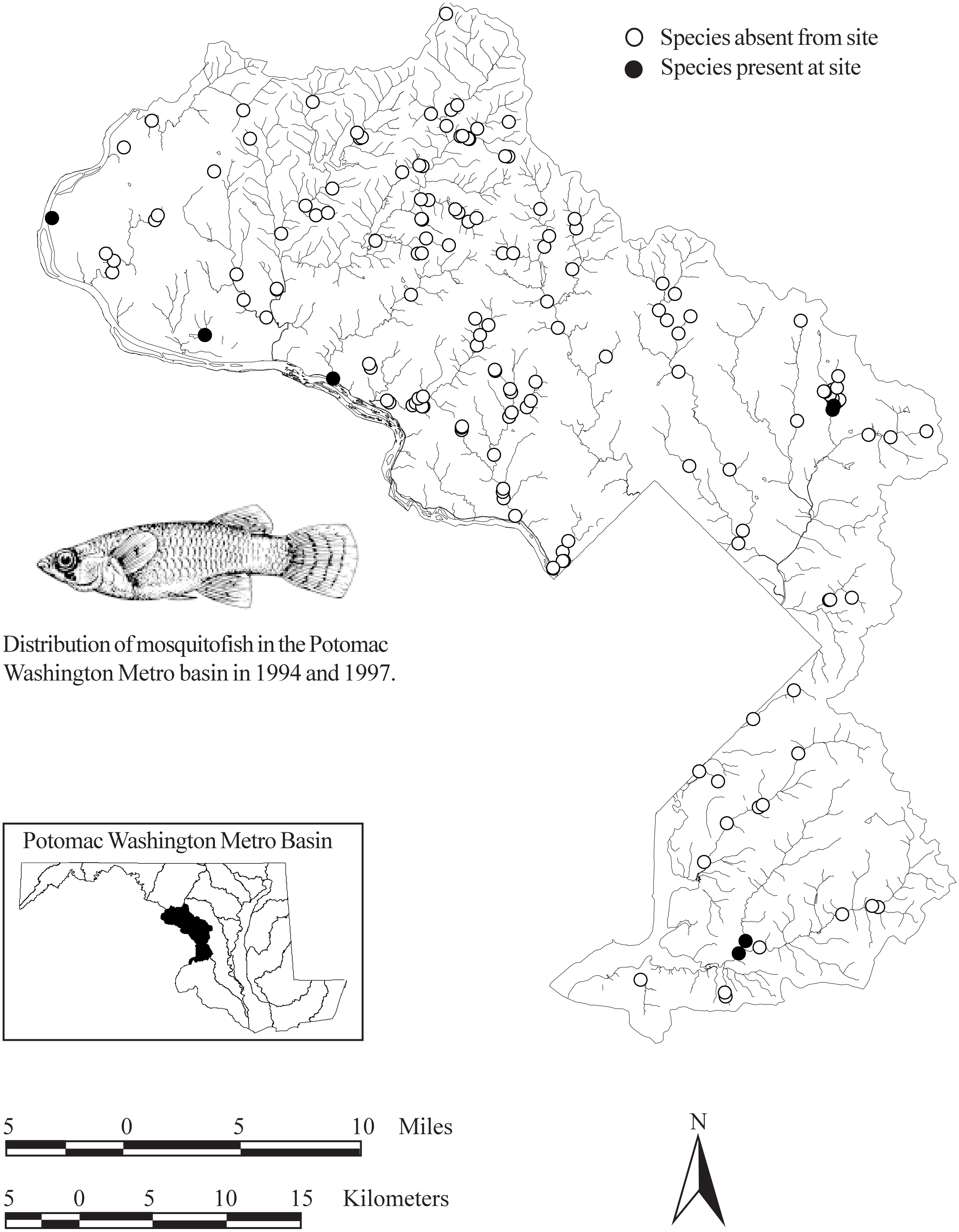




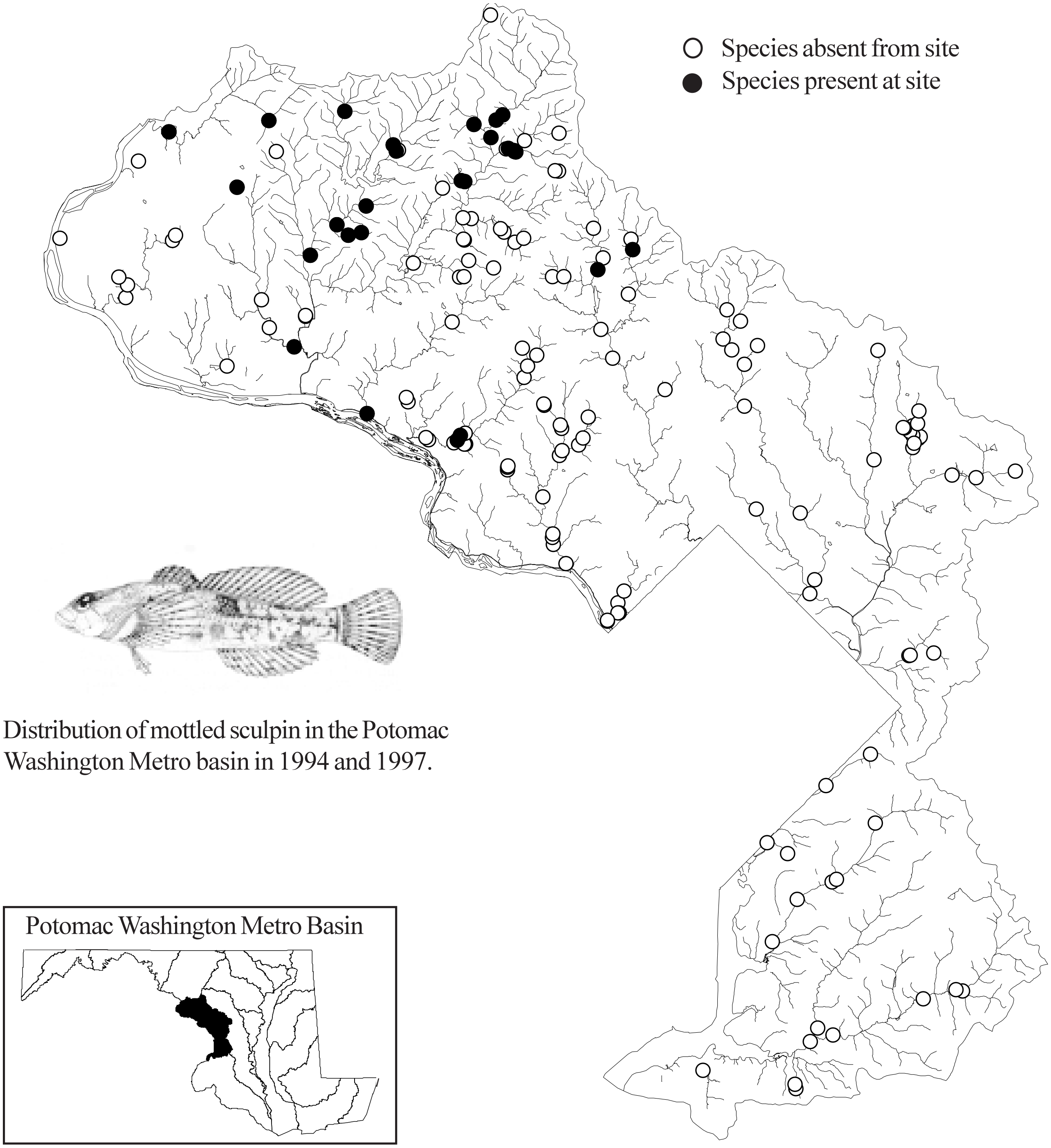
Distribution of banded killifish in the Potomac Washington Metro basin in 1994 and 1997.



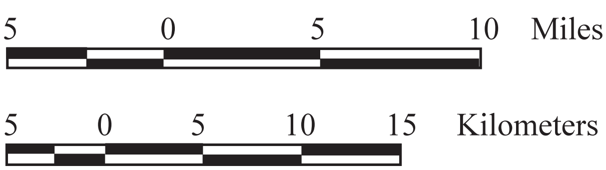
Distribution of mummichog in the Potomac Washington Metro basin in 1994 and 1997.

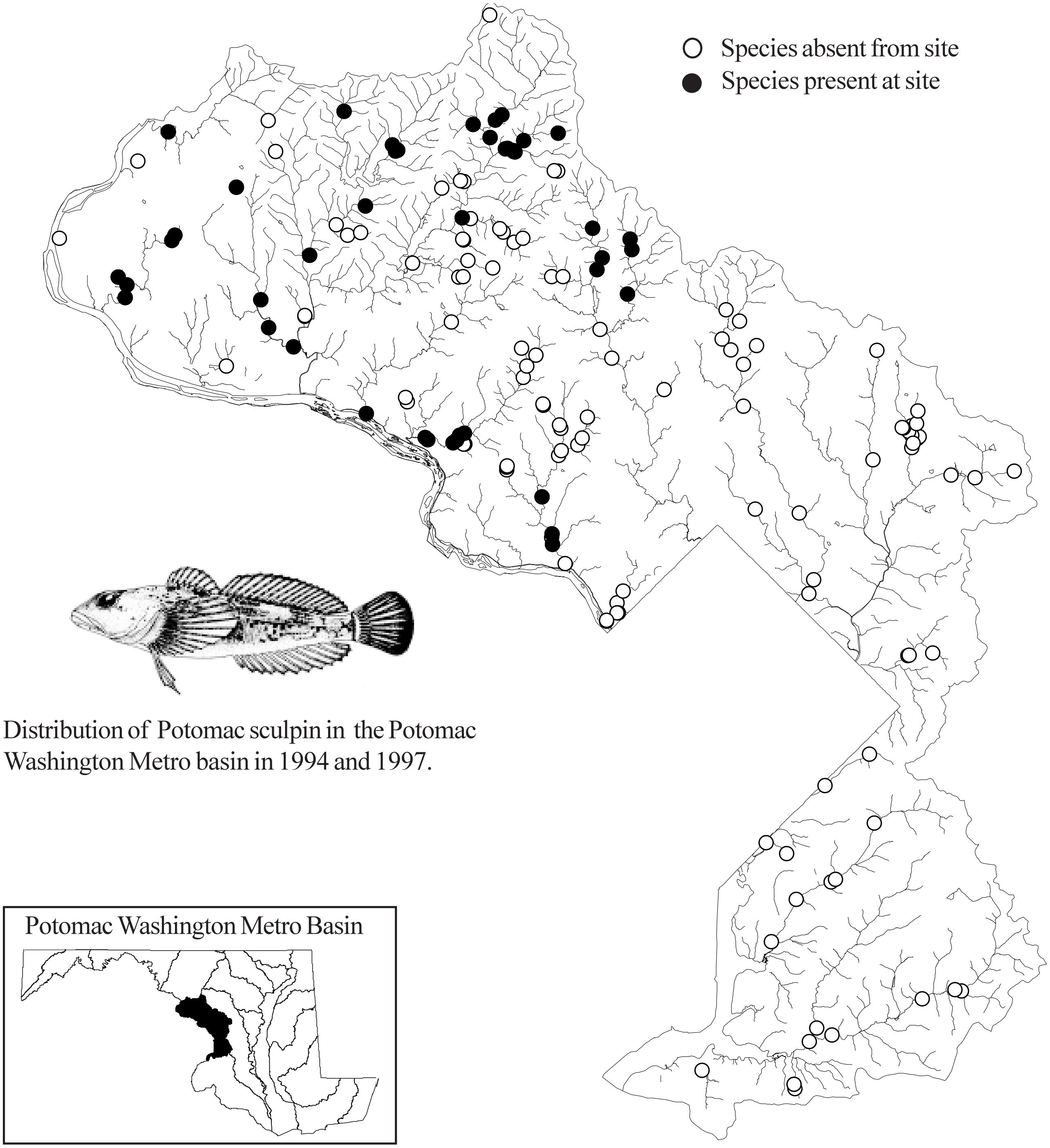


Distribution of mosquitofish in the Potomac Washington Metro basin in 1994 and 1997.

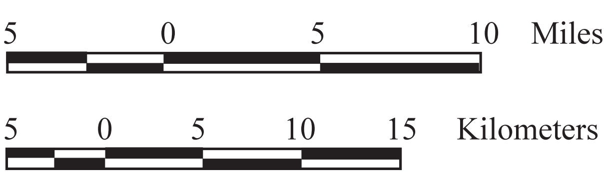


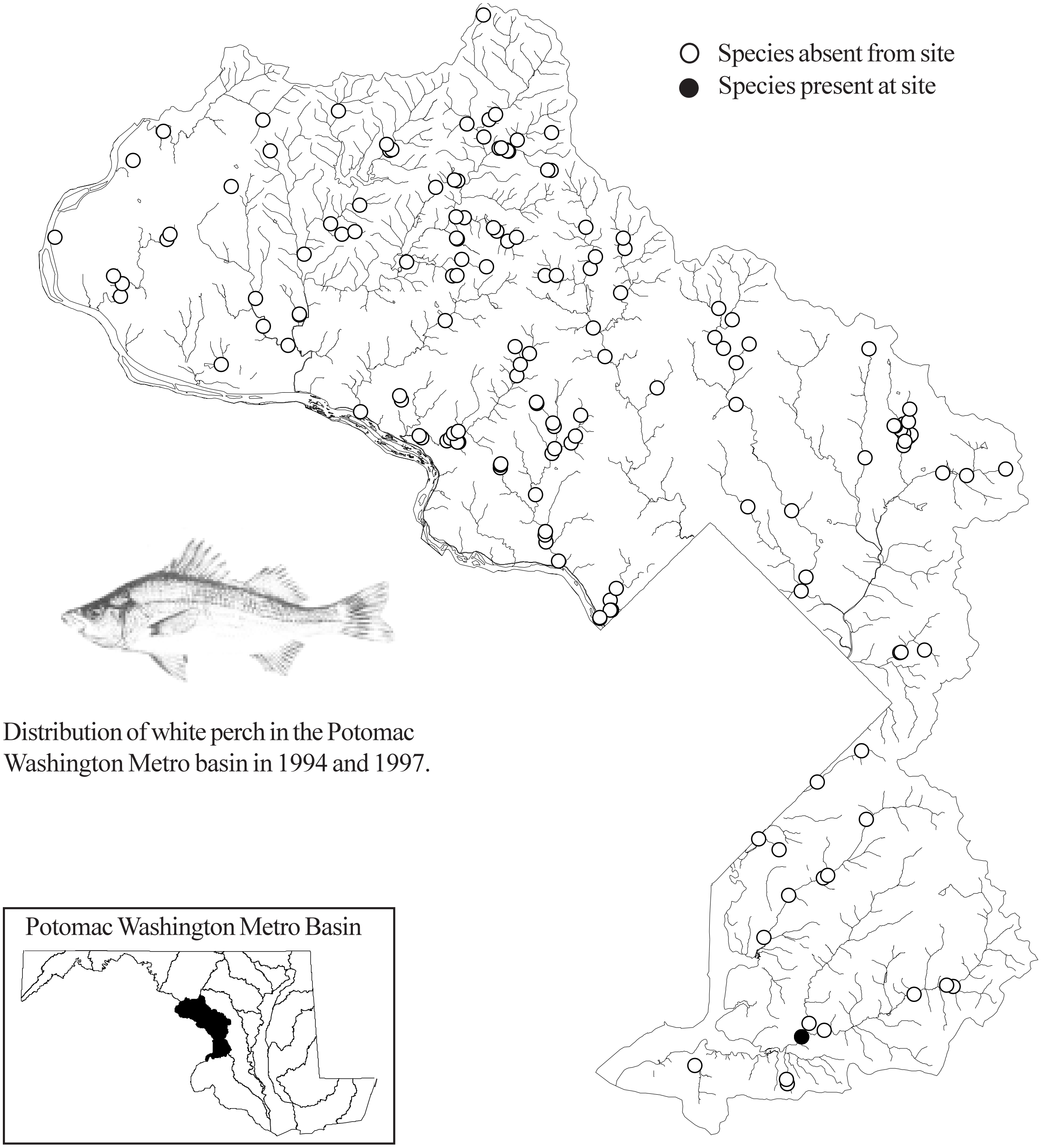
Distribution of mottled sculpin in the Potomac Washington Metro basin in 1994 and 1997.



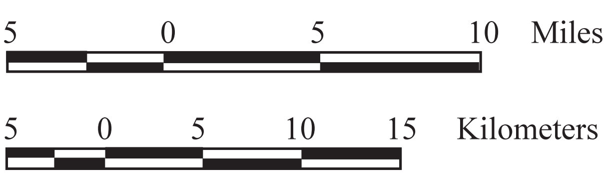


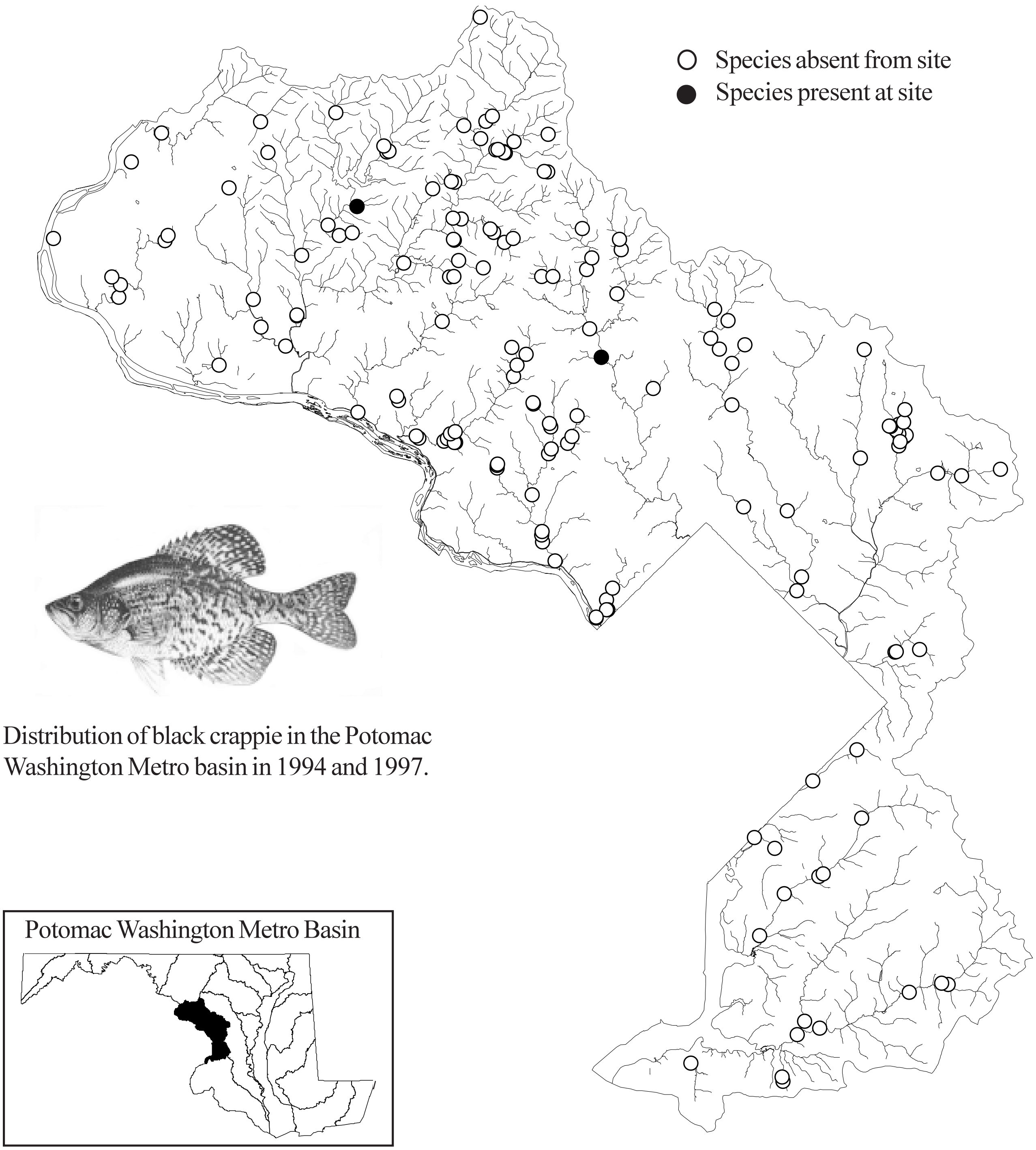
Distribution of Potomac sculpin in the Potomac Washington Metro basin in 1994 and 1997.



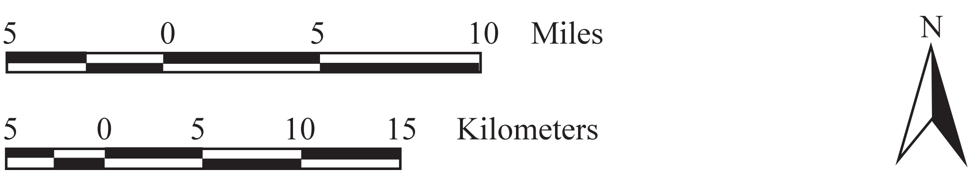


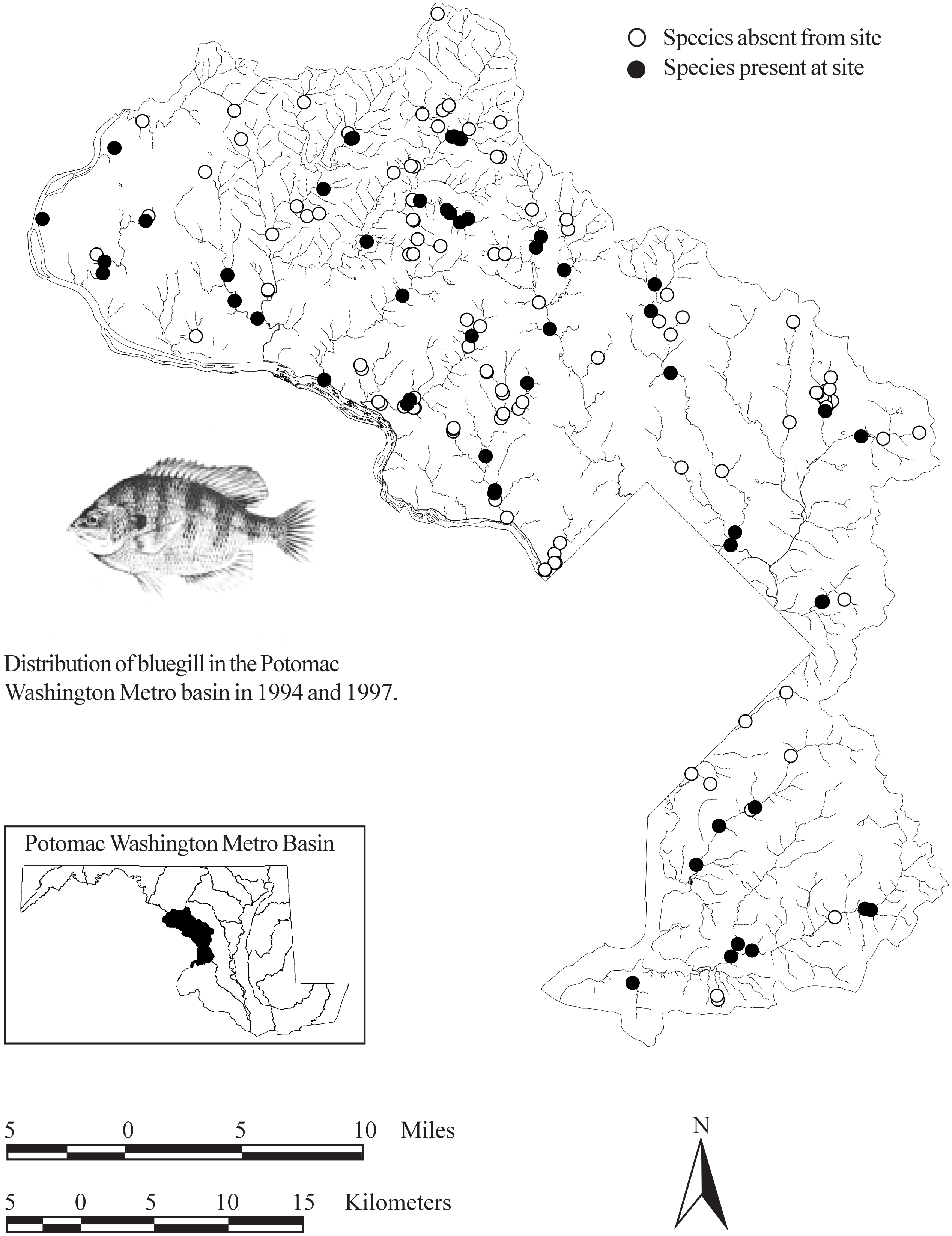
Distribution of white perch in the Potomac Washington Metro basin in 1994 and 1997.



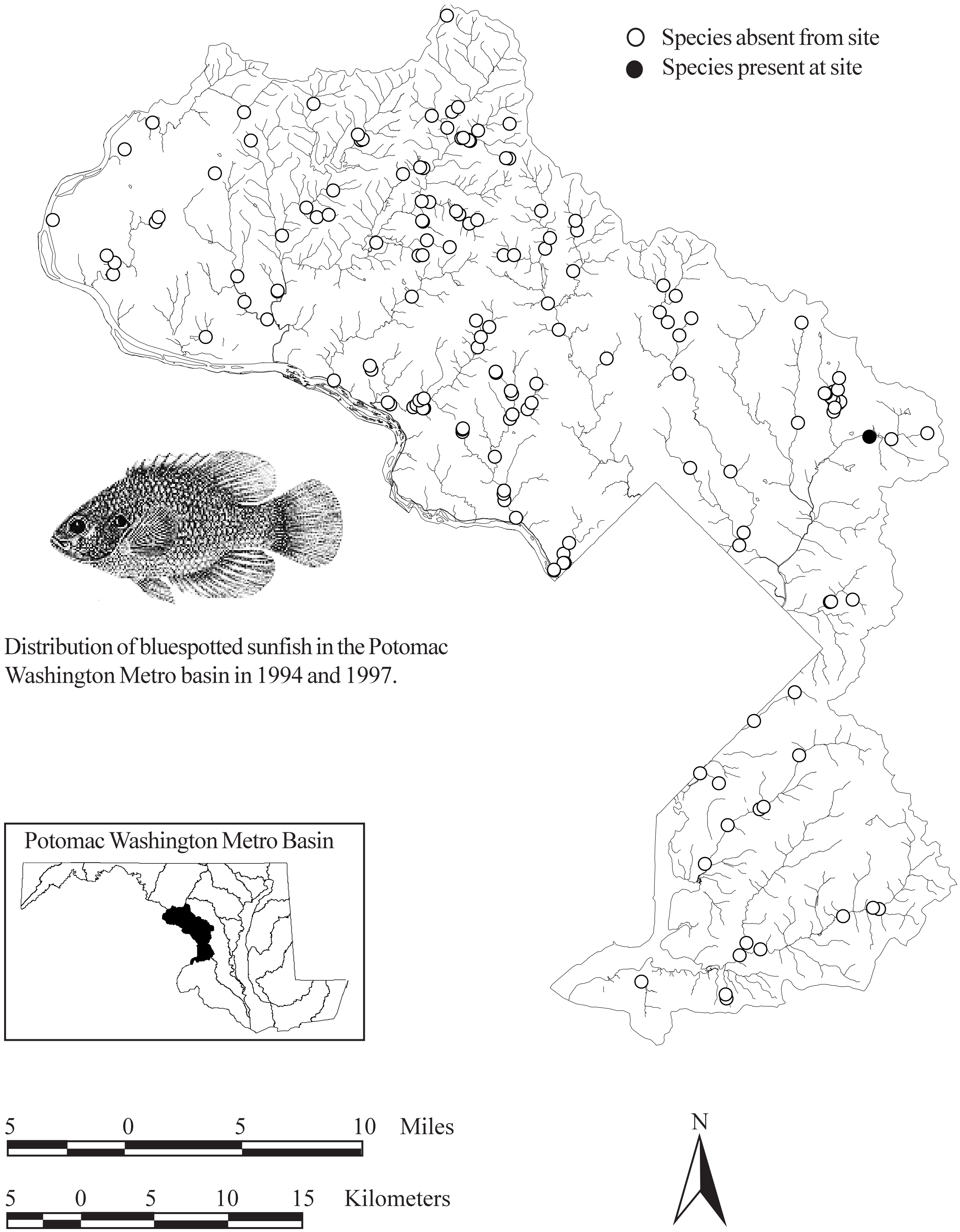


Distribution of black crappie in the Potomac Washington Metro basin in 1994 and 1997.

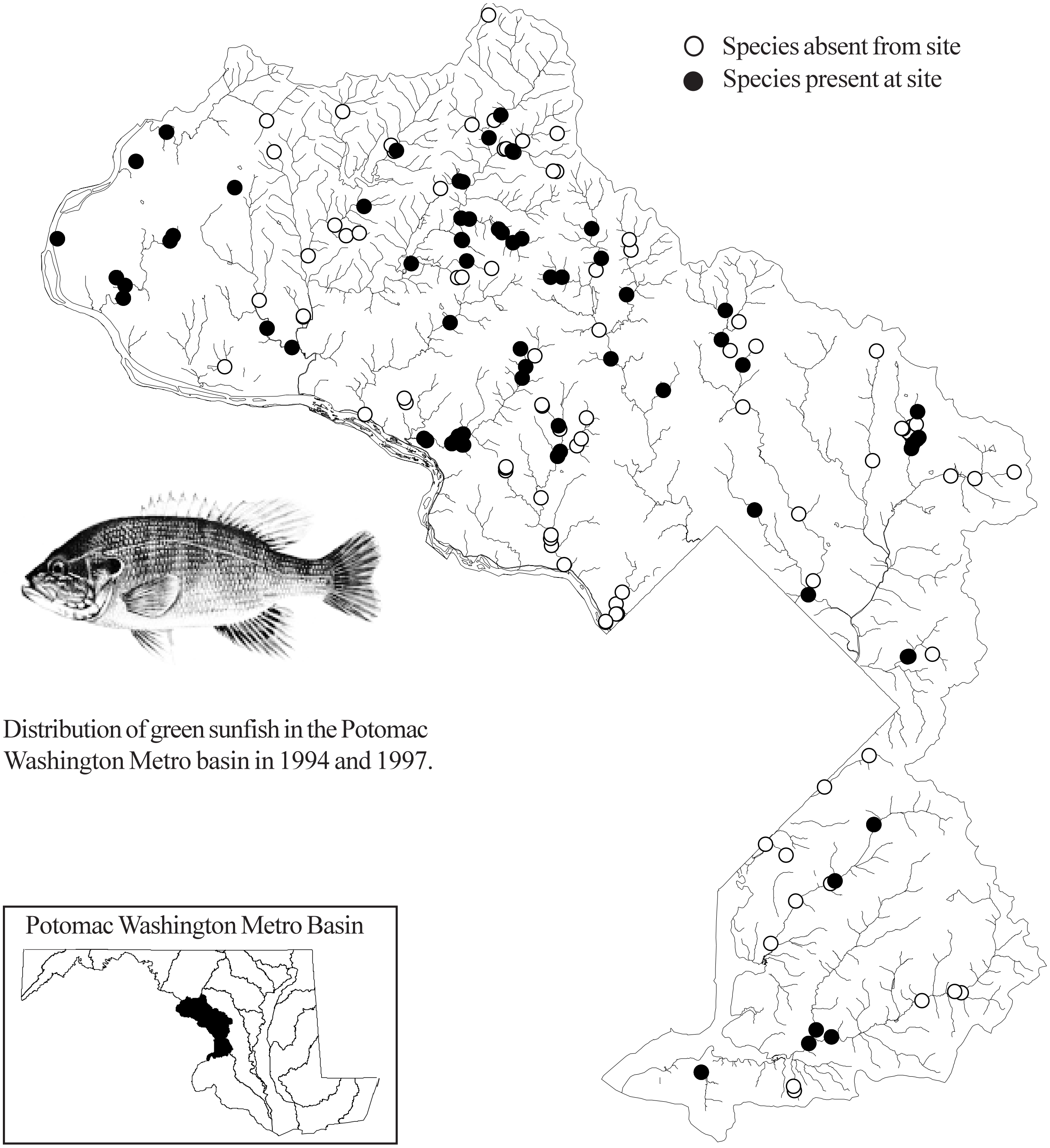




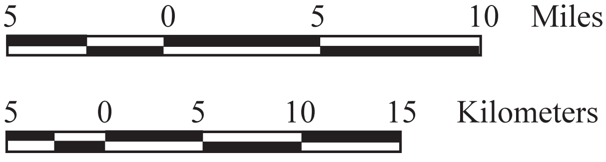
Distribution of bluegill in the Potomac Washington Metro basin in 1994 and 1997.

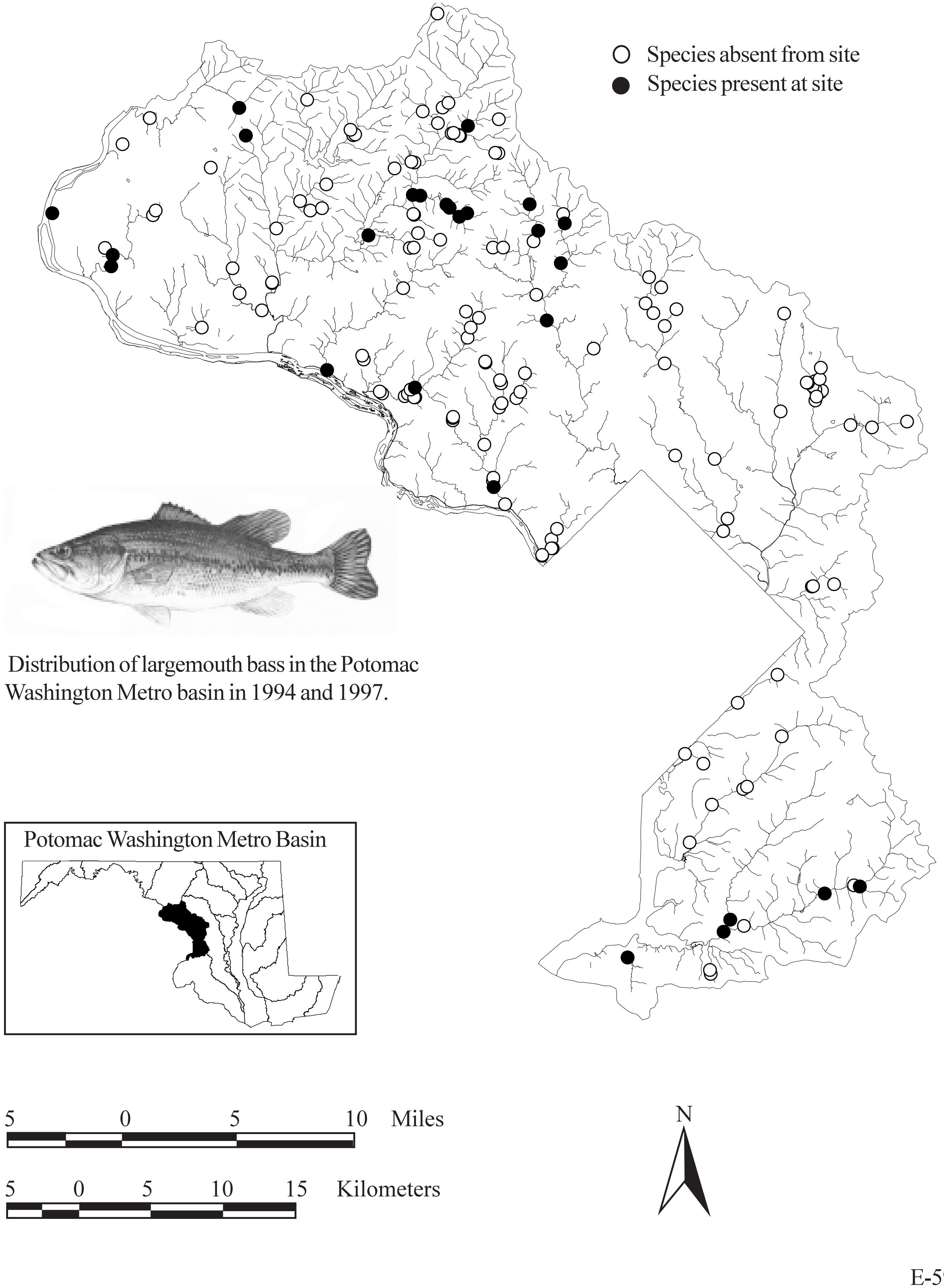


Distribution of bluespotted sunfish in the Potomac Washington Metro basin in 1994 and 1997.

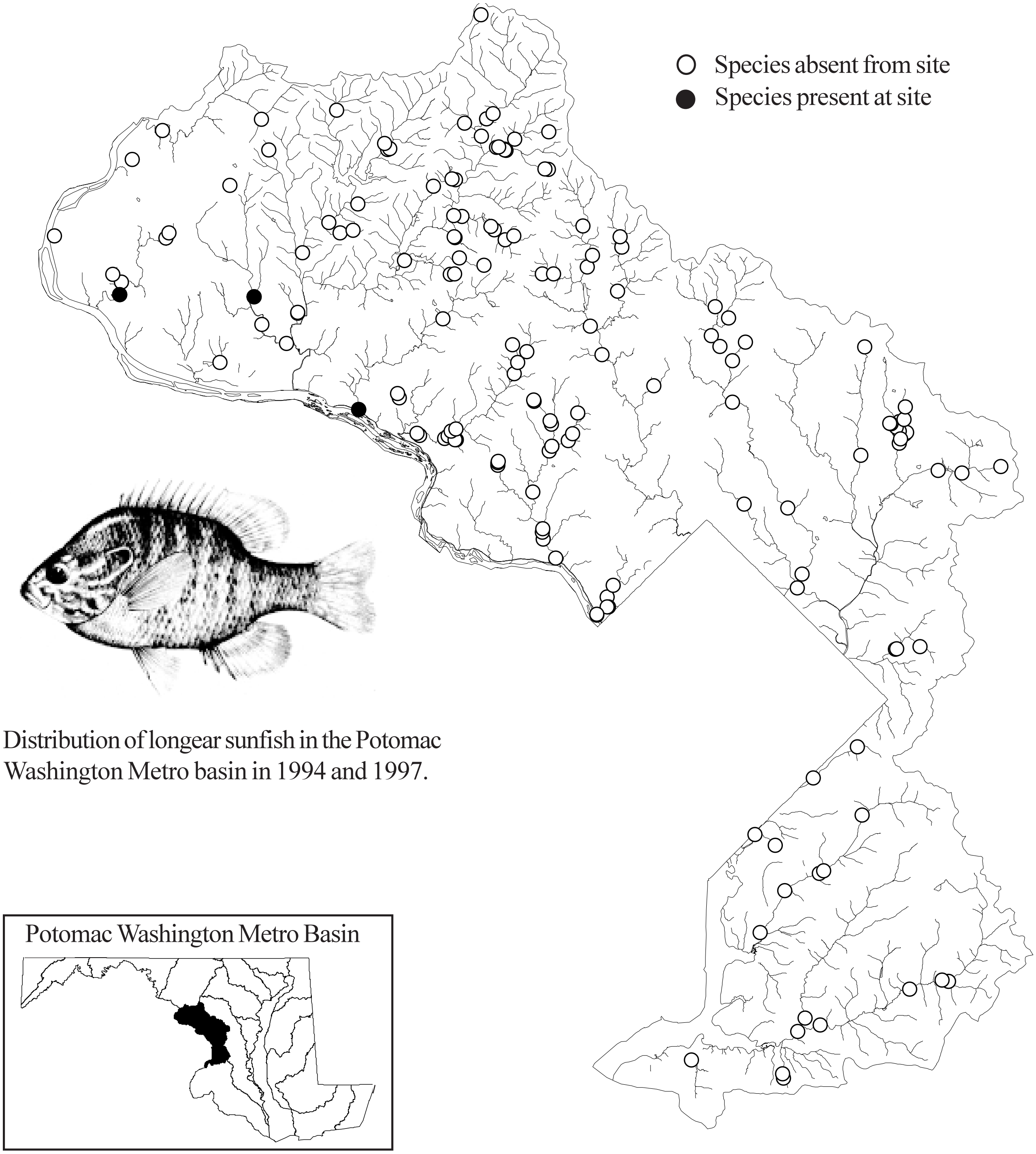


Distribution of green sunfish in the Potomac Washington Metro basin in 1994 and 1997.

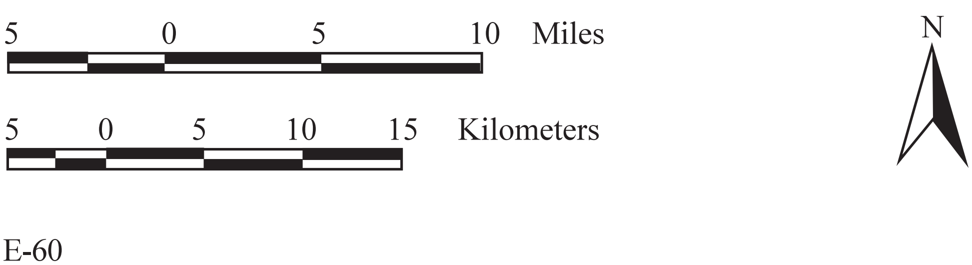


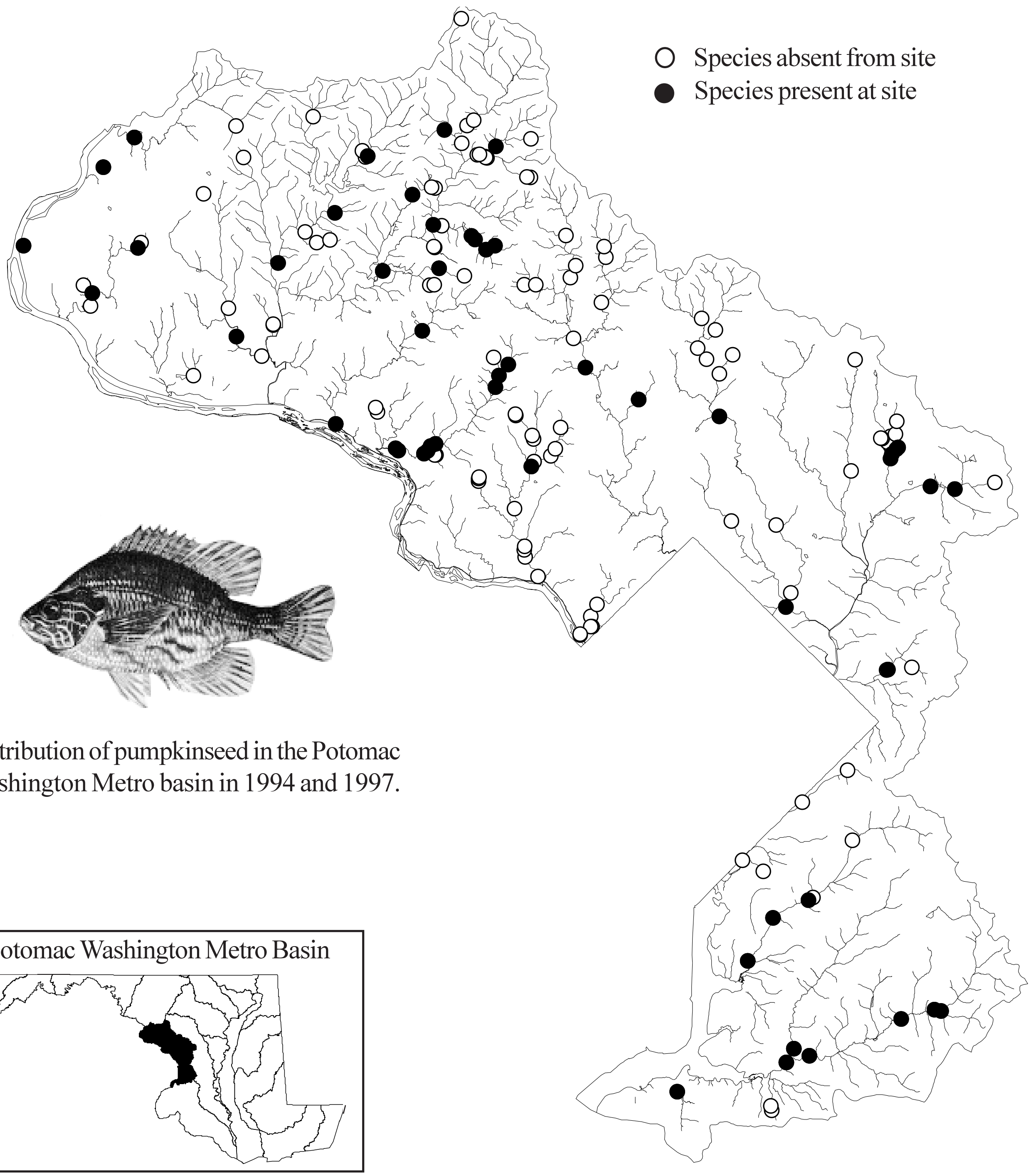


Distribution of largemouth bass in the Potomac Washington Metro basin in 1994 and 1997.

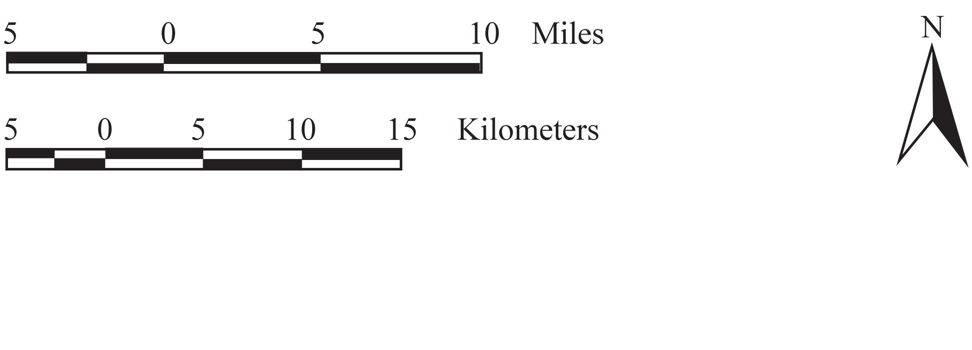


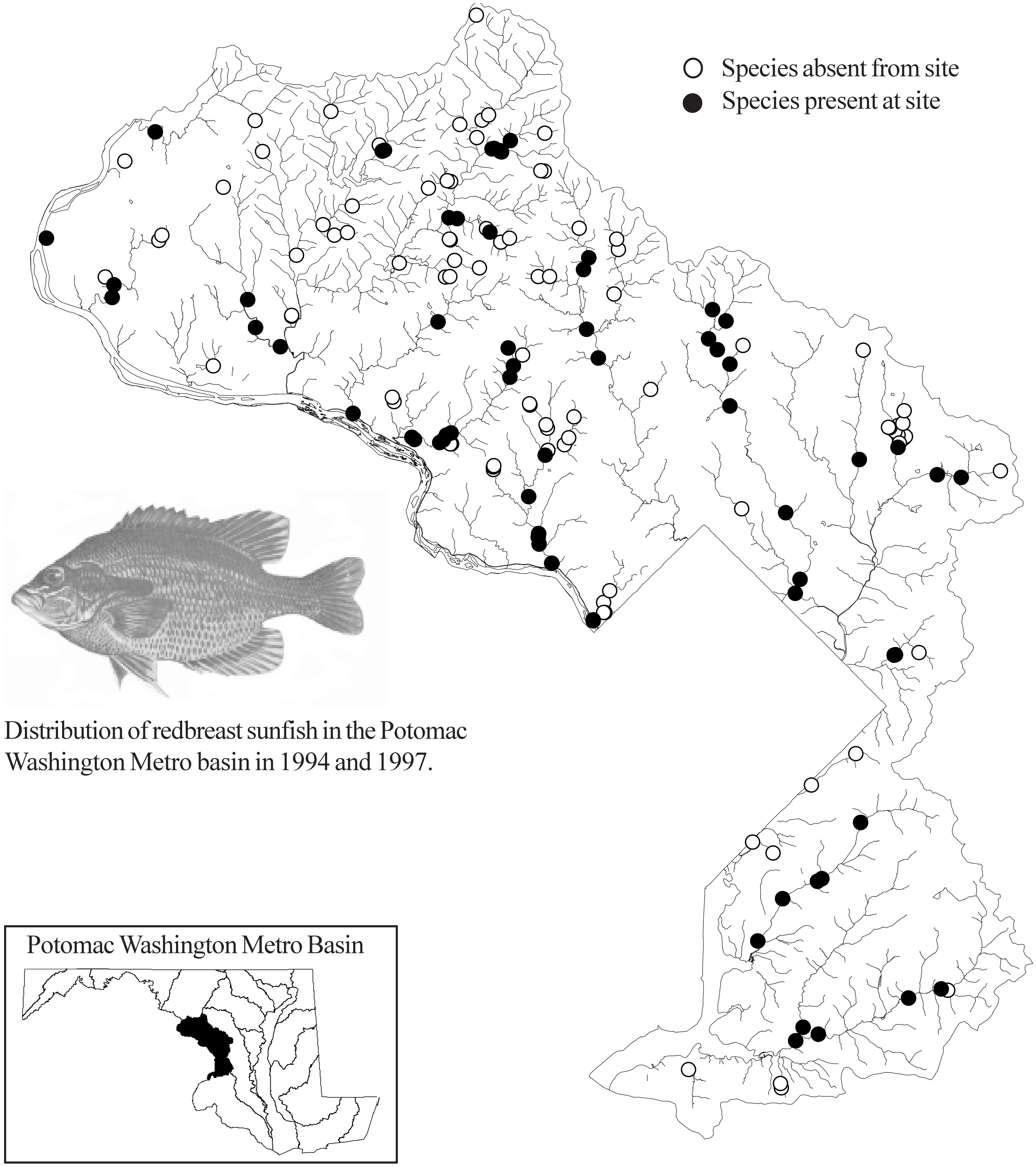
Distribution of longear sunfish in the Potomac Washington Metro basin in 1994 and 1997.



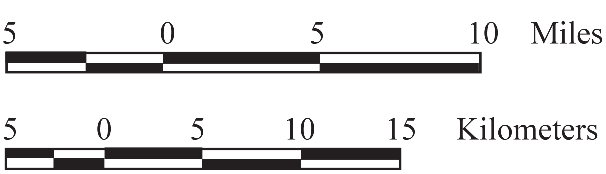


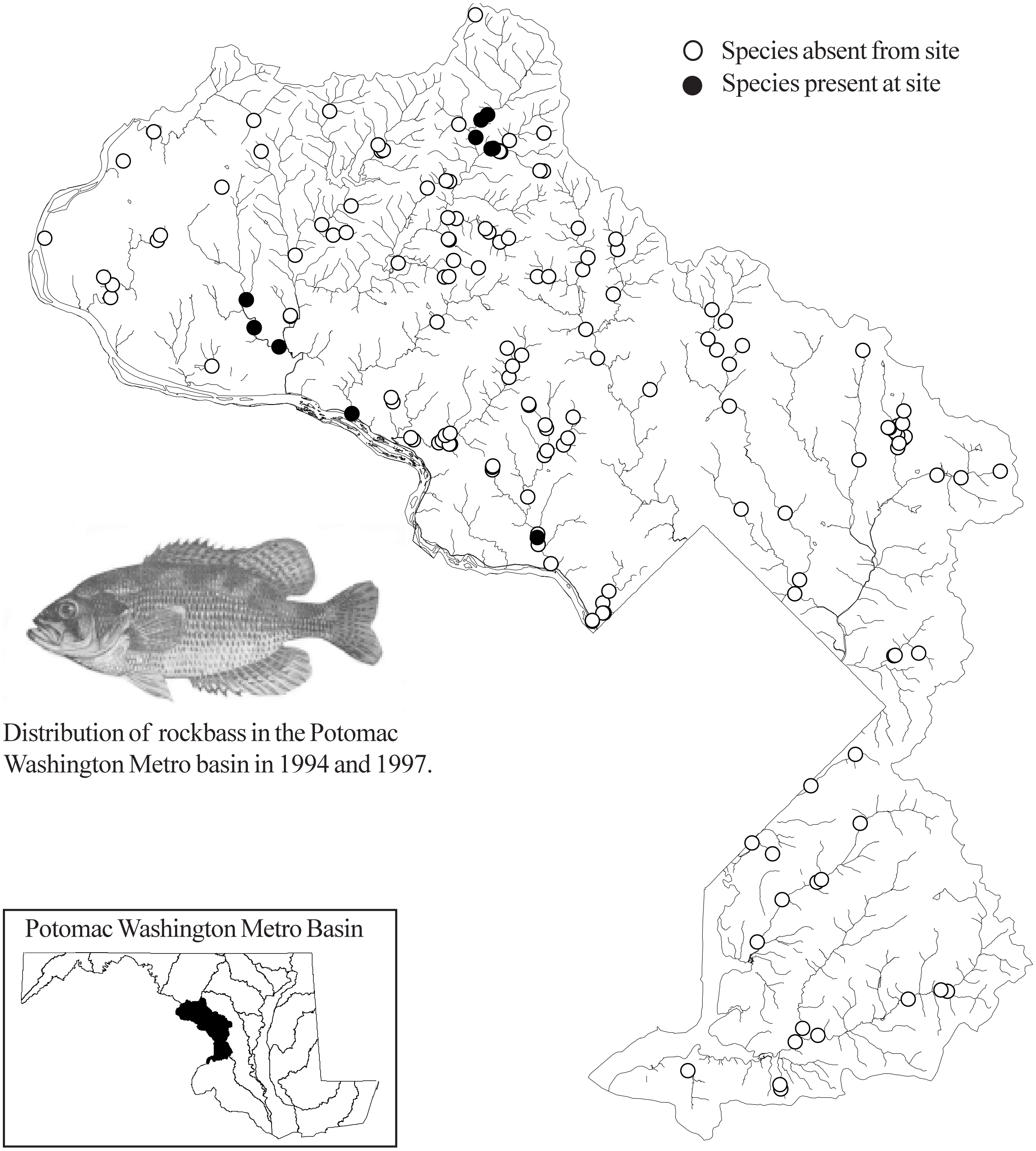
Distribution of pumpkinseed in the Potomac Washington Metro basin in 1994 and 1997.



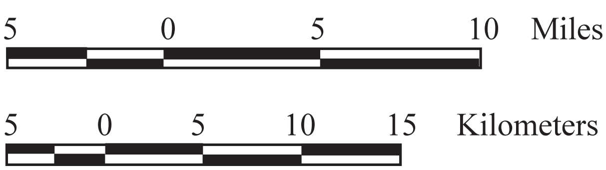


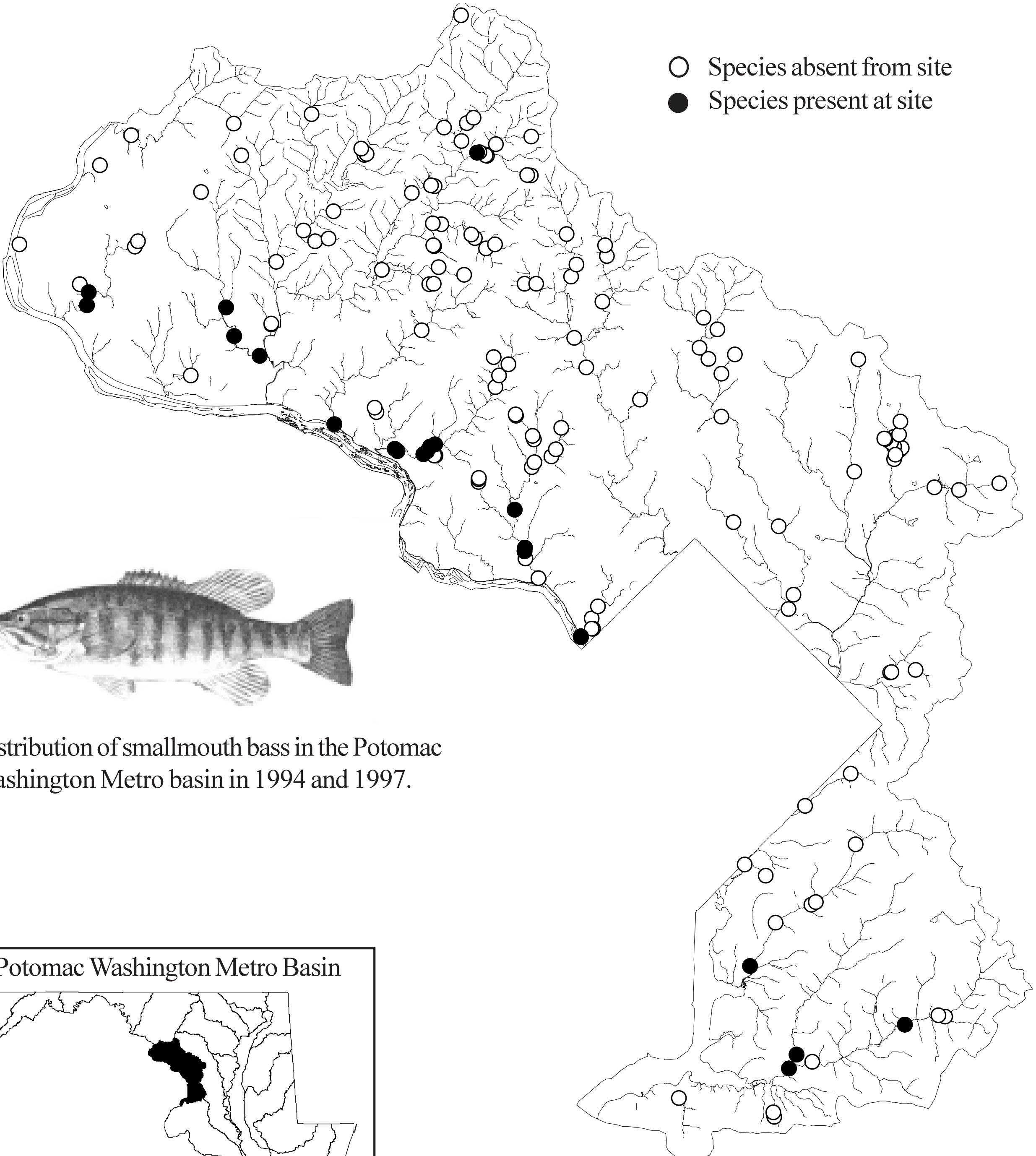
Distribution of redbreast sunfish in the Potomac Washington Metro basin in 1994 and 1997.



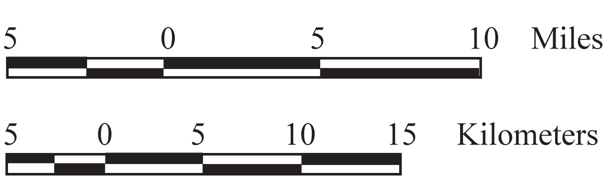


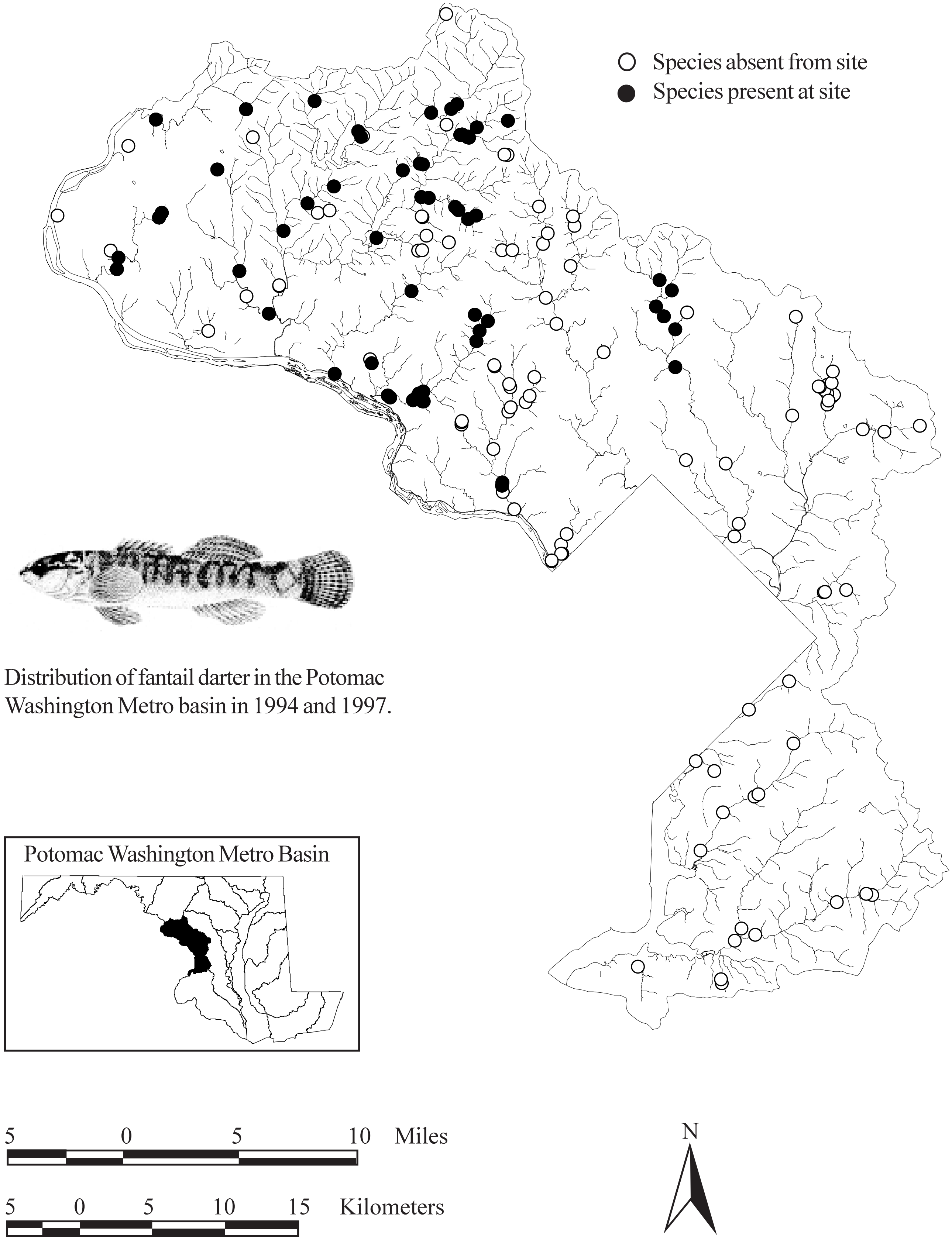
Distribution of rockbass in the Potomac Washington Metro basin in 1994 and 1997.



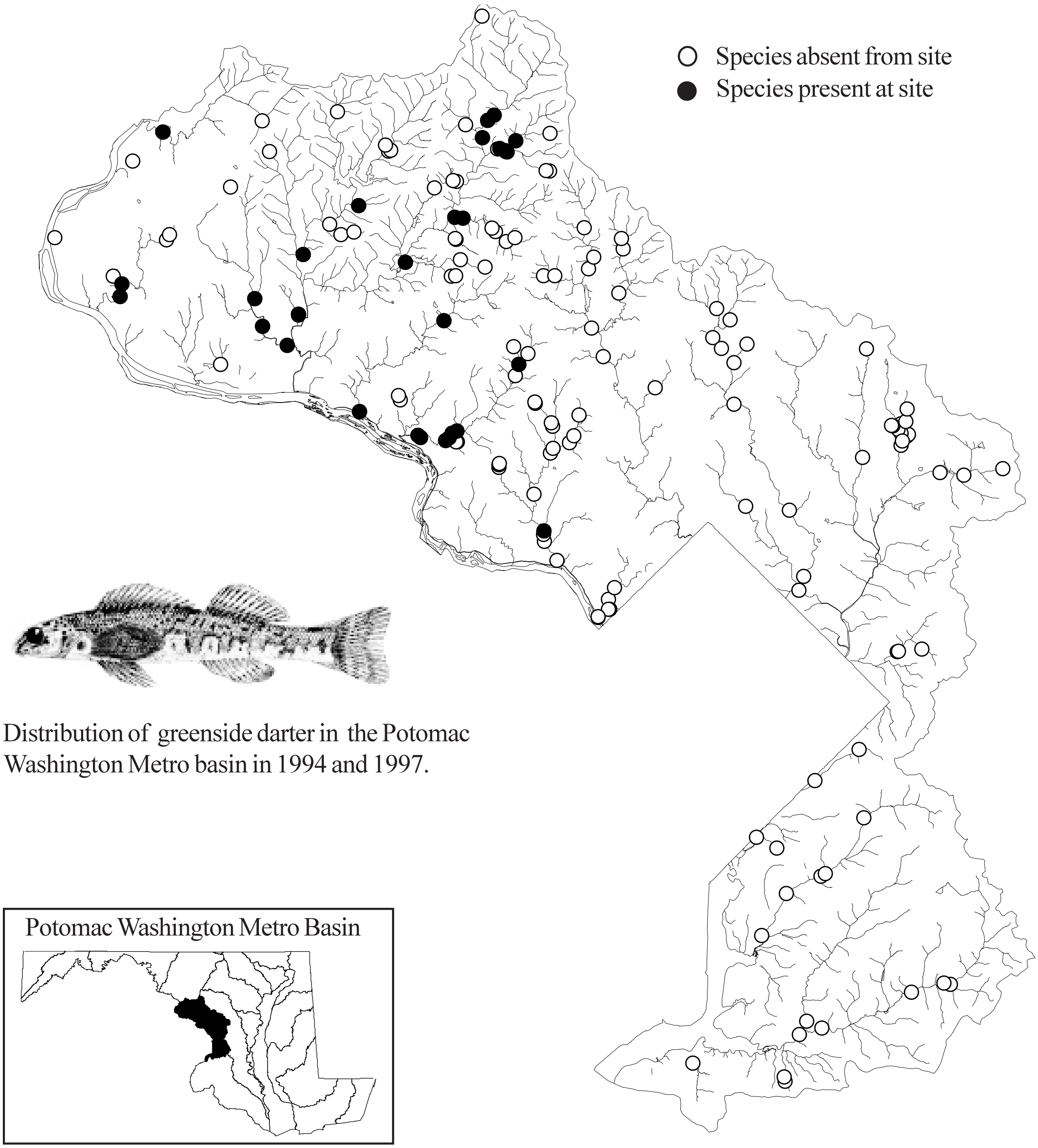


Distribution of smallmouth bass in the Potomac Washington Metro basin in 1994 and 1997.

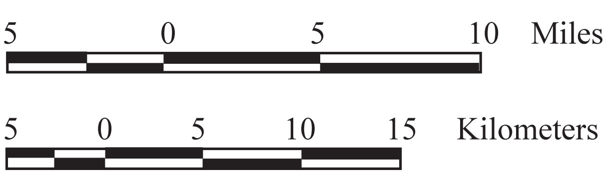


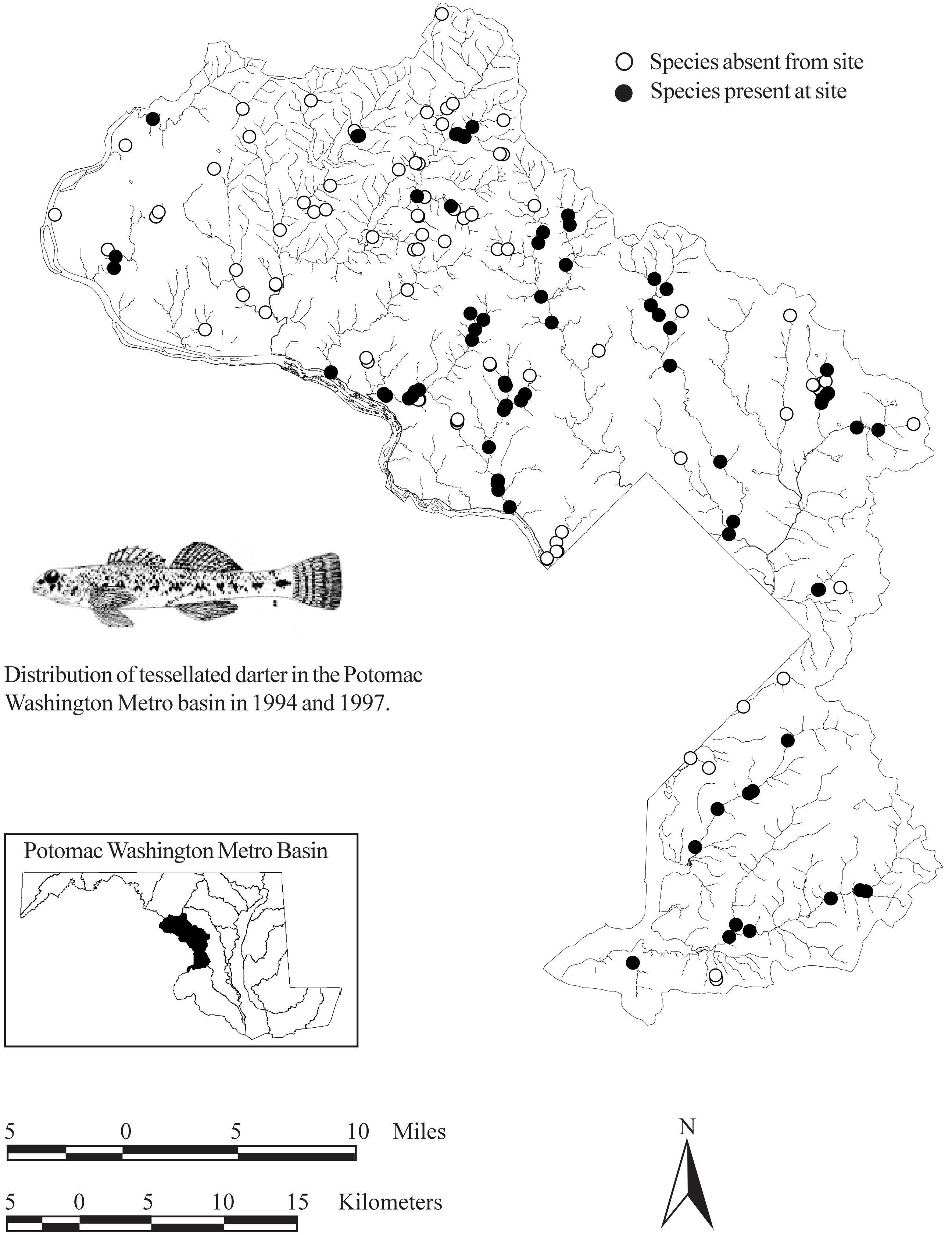


Distribution of fantail darter in the Potomac Washington Metro basin in 1994 and 1997.



Distribution of greenside darter in the Potomac Washington Metro basin in 1994 and 1997.





Distribution of tessellated darter in the Potomac Washington Metro basin in 1994 and 1997.

Appendix F. Benthic macroinvertebrate taxa with designated tolerance value (TV; 10 = most tolerant, 0 = least tolerant), functional feeding groups (FFG), habit, and percent occurrence (% Occ) for the 1997 MBSS sites in the Potomac Washington Metro Basin. Abbreviations of habits are as follows: bu - burrower, cn - clinger, sp - spawler, cb - climber, sw -swimmer, dv - diver, sk - skater.

Class	Order	Family	Genus	TV	FFG	Habit	%Occ
Nematomorpha						bu	8.5
Enopla	Hoplonemertea	Tetrastemmatidae	*Prostoma*		Predator	Unknown	8.5
Turbellaria	Tricladida	Planariidae	*Cura*		Unknown	sp	1.4
			Dugesia	7	Predator	sp	11.3
Oligochaeta	Lumbriculida	Lumbriculidae		10	Collector	bu	29.6
	Tubificida	Enchytraeidae		10	Collector	bu	15.5
		Naididae		10	Collector	bu	71.8
		Tubificidae	*Limnodrilus*	10	Collector	cn	9.9
Hirudinea	Rhynchobdellida	Glossiphoniidae	*Helobdella*		Predator	sp	1.4
Gastropoda	Basommatophora	Ancylidae	*Ferrissia*	7	Scraper	cb	2.8
		Lymnaeidae	*Pseudosuccinea*	6	Collector	cb	1.4
		Physidae	*Physella*	8	Scraper	cb	15.5
		Planorbidae	*Menetus*	8	Scraper	cb	1.4
Pelecypoda	Veneroida	Corbiculidae	*Corbicula*	6	Filterer	bu	4.2
		Sphaeriidae	*Pisidium*	8	Filterer	bu	7.0
			Sphaerium	8	Filterer	bu	7.0
Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	4	Collector	sp	18.3
		Gammaridae	*Gammarus*	6	Shredder	sp	1.4
			Stygonectes	6	Shredder	sp	1.4
		Hyalellidae	*Hyalella*	6	Shredder	sp	1.4
		Naididae					71.8
	Decapoda	Cambaridae	*Orconectes*	6	Shredder	sp	1.4
	Isopoda	Asellidae	*Caecidotea*	8	Collector	sp	8.5
Insecta	Ephemeroptera	Ameletidae	*Ameletus*	0	Collector	sw, cb	5.6
		Baetidae	*Acentrella*	4	Collector	sw, cn	1.4
			Acerpenna	4	Collector	sw, cn	19.7
			Baetis	6	Collector	sw, cb, cn	11.3
			Centroptilum	2	Collector	sw, cn	2.8
			Procloeon	4	Collector	Unknown	1.4
		Caenidae	*Caenis*	7	Collector	sp	4.2
		Ephemerellidae	*Drunella*	1	Scraper	cn, sp	1.4
			Ephemerella	2	Collector	cn, sw	26.8
			Eurylophella	4	Scraper	cn, sp	11.3
			Serratella	2	Collector	cn	4.2
		Heptageniidae	*Epeorus*	0	Scraper	cn	1.4
			Heptagenia	4	Scraper	cn, sw	1.4
			Stenacron	4	Collector	cn	2.8
			Stenonema	4	Scraper	cn	25.4
		Isonychiidae	*Isonychia*	2	Filterer	sw, cn	11.3
		Leptophlebiidae	*Leptophlebia*	4	Collector	sw, cn, sp	2.8
			Paraleptophlebia	2	Collector	sw, cn, sp	11.3
		Siphlonuridae	*Siphlonurus*	7	Collector	sw, cb	2.8
Insecta	Odonata	Aeshnidae	*Boyeria*	2	Predator	cb, sp	7.0
		Calopterygidae	*Calopteryx*	6	Predator	cb	4.2
		Coenagrionidae	*Argia*	8	Predator	cn, cb, sp	7.0
			Ischnura	9	Predator	cb	1.4

Class	Order	Family	Genus	TV	FFG	Habit	%Occ
		Cordulegastridae	*Cordulegaster*	3	Predator	bu	2.8
		Corduliidae	*Macromia*	3	Predator	sp	2.8
		Gomphidae	*Stylogomphus*		Predator	bu	1.4
Insecta	Plecoptera	Capniidae	*Allocapnia*	3	Shredder	cn	2.8
			Paracapnia	1	Shredder	Unknown	2.8
		Chloroperlidae	*Haploperla*		Predator	cn	1.4
			Perlinella		Predator	cn	1.4
		Leuctridae	*Leuctra*	0	Shredder	cn	7.0
		Nemouridae	*Amphinemura*	3	Shredder	sp, cn	39.4
			Prostoia		Shredder	sp, cn	22.5
		Perlidae	*Eccoptura*		Predator	cn	1.4
		Perlodidae	*Clioperla*	1	Predator	cn	2.8
			Isoperla	2	Predator	cn, sp	11.3
		Taeniopterygidae	*Oemopteryx*		Shredder	sp, cn	1.4
			Strophopteryx		Shredder	sp, cn	9.9
Insecta	Megaloptera	Corydalidae	*Corydalus*	5	Predator	cn, cb	1.4
Insecta	Trichoptera	Glossosomatidae	*Agapetus*	2	Scraper	cn	1.4
			Glossosoma	0	Scraper	cn	1.4
		Hydropsychidae	*Cheumatopsyche*	5	Filterer	cn	43.7
			Diplectrona	2	Filterer	cn	16.9
			Hydropsyche	6	Filterer	cn	49.3
		Hydroptilidae	*Hydroptila*	6	Scraper	cn	1.4
		Lepidostomatidae	*Lepidostoma*	3	Shredder	cb, sp, cn	2.8
		Leptoceridae	*Oecetis*	8	Predator	cn, sp, cb	1.4
		Limnephilidae	*Ironoquia*	3	Shredder	sp	1.4
			Pycnopsyche	4	Shredder	sp, cb, cn	1.4
		Philopotamidae	*Chimarra*	4	Filterer	cn	12.7
			Dolophilodes	0	Filterer	cn	5.6
		Polycentropodidae	*Polycentropus*	5	Filterer	cn	4.2
		Psychomyiidae	*Lype*	2	Scraper	cn	2.8
		Rhyacophilidae	*Rhyacophila*	1	Predator	cn	2.8
		Uenoidae	*Neophylax*	3	Scraper	cn	11.3
Insecta	Coleoptera	Dryopidae	*Helichus*	5	Scraper	cn	2.8
		Dytiscidae	*Agabus*	5	Predator	sw, dv	2.8
		Elmidae	*Ancyronyx*	2	Scraper	cn, sp	7.0
			Dubiraphia	6	Scraper	cn, cb	5.6
			Macronychus	4	Scraper	cn	2.8
			Optioservus	4	Scraper	cn	21.1
			Oulimnius	2	Scraper	cn	23.9
			Stenelmis	6	Scraper	cn	23.9
		Gyrinidae	*Gyrinus*	4	Predator	sw, dv	2.8
		Haliplidae	*Peltodytes*	5	Shredder	cb, cn	1.4
		Hydrophilidae	*Berosus*	5	Collector	sw, dv, cb	1.4
			Hydrobius	5	Collector	cb, cn, sp	1.4
		Psephenidae	*Psephenus*	4	Scraper	cn	1.4
		Ptilodactylidae	*Anchytarsus*	4	Shredder	cn	7.0
Insecta	Diptera	Ceratopogonidae	*Bezzia*	6	Predator	bu	1.4
			Ceratopogon	6	Predator	sp, bu	7.0
			Culicoides	10	Predator	bu	4.2

Class	Order	Family	Genus	TV	FFG	Habit	%Occ
			Probezzia	6	Predator	bu	5.6
		Chironomidae	*Ablabesymia*	8	Predator	sp	2.8
			Brillia	5	Shredder	bu, sp	18.3
			Cardiocladius	6	Predator	bu, cn	1.4
			Chaetocladius	6	Collector	sp	1.4
			Conchapelopia	6	Predator	sp	52.1
			Corynoneura	7	Collector	sp	21.1
			Cricotopus	7	Shredder	cn, bu	19.7
			Cricotopus/Orthocladius		Shredder	Unknown	93.0
			Cryptochironomus	8	Predator	sp, bu	7.0
			Diamesa	5	Collector	sp	43.7
			Dicrotendipes	10	Collector	bu	2.8
			Diplocladius	7	Collector	sp	4.2
			Endochironomus	10	Shredder	cn	1.4
			Eukiefferiella	8	Collector	sp	57.7
			Heleniella		Predator	sp	1.4
			Heterotrissocladius		Collector	sp, bu	2.8
			Hydrobaenus	8	Scraper	sp	4.2
			Krenopelopia		Predator	sp	1.4
			Meropelopia	7	Unknown	Unknown	2.8
			Micropsectra	7	Collector	cb, sp	9.9
			Microtendipes	6	Filterer	cn	4.2
			Nanocladius	3	Collector	sp	12.7
			Natarsia	8	Predator	sp	2.8
			Orthocladiinae A	6	Collector	sp, bu	46.5
			Orthocladius	6	Collector	sp, bu	4.2
			Paramerina	4	Predator	sp	1.4
			Parametriocnemus	5	Collector	sp	57.7
			Paratanytarsus	6	Collector	sp	14.1
			Paratendipes	8	Collector	bu	1.4
			Phaenopsectra	7	Collector	cn	1.4
			Polypedilum	6	Shredder	cb, cn	52.1
			Potthastia	2	Collector	sp	1.4
			Rheocricotopus	6	Collector	sp	35.2
			Rheotanytarsus	6	Filterer	cn	28.2
			Saetheria	4	Collector	bu	1.4
			Stempellinella	4	Collector	cb, sp, cn	2.8
			Stenochironomus	5	Shredder	bu	7.0
			Sublettea		Collector	Unknown	1.4
			Symposiocladius		Predator	sp	4.2
			Sympotthastia	2	Collector	sp	14.1
			Tanytarsus	6	Filterer	cb, cn	26.8
			Thienemanniella	6	Collector	sp	35.2
			Thienemannimyia		Predator	sp	21.1
			Tribelos	5	Collector	bu	1.4
			Trissopelopia		Predator	sp	16.9
			Tvetenia	5	Collector	sp	5.6

Class	Order	Family	Genus	TV	FFG	Habit	%Occ
			Unniella		Collector	Unknown	2.8
			Xylotopus	2	Shredder	bu	1.4
			Zavrelimyia	8	Predator	sp	8.5
		Dolichopodidae			Predator	sp, bu	1.4
		Dixidae	*Dixa*	4	Predator	sw, cb	1.4
		Empididae	*Chelifera*		Predator	sp, bu	16.9
			Clinocera		Predator	cn	22.5
			Hemerodromia	6	Predator	sp, bu	36.6
		Simuliidae	*Prosimulium*	7	Filterer	cn	33.8
			Simulium	7	Filterer	cn	28.2
			Stegopterna	7	Filterer	cn	14.1
		Tabanidae	*Chrysops*	7	Predator	sp, bu	1.4
		Tipulidae	*Antocha*	5	Collector	cn	29.6
			Dicranota	4	Predator	sp, bu	9.9
			Hexatoma	4	Predator	bu, sp	5.6
			Ormosia		Collector	bu	2.8
			Pseudolimnophila	2	Predator	bu	2.8
			Tipula	4	Shredder	bu	21.1